E OXFORD GEOGRAPHIES

AUSTRALIA

IYSIOGRAPHIC & ECONOMIC

BY

GRIFFITH TAYLOR

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EDITED BY A. J. HERBERTSON

AUSTRALIA

IN ITS PHYSIOGRAPHIC AND ECONOMIC ASPECTS

BY

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PREFACE TO FIRST EDITION

The present work is merely an *Introduction* to the study of the Commercial Geography of Australia. I have endeavoured to avoid bare statistics, and, humbly following the plan of Mackinder, Davis, and other modern geographers, to lay the most stress on the physical controls which govern the industrial conditions in our Island Continent.

There has been no attempt to give an exhaustive account either of the physiographic or of the economic aspects of Australia. This would not be advisable for several reasons; but the main industries in each State, especially such as are characteristic of Australian environment, have been chosen for fuller treatment. In dealing with them, their relation to Geology and Climate (more particularly to rainfall) is discussed, as well as their distribution. In a few cases some brief technological notes are added. A glance at the list of sections will show that some States must be more fully treated than others. New South Wales is most important for Wool and Coal; Queensland for Cattle and Sugar; Victoria for Irrigation and other problems of Intense Cultivation; South Australia for Wheat, and so on.

I have endeavoured to acknowledge material borrowed from other works—almost wholly Government publications—in the text, but I am under great obligation to Professor David, F.R.S. (University of Sydney); to Mr. H. C. L. Anderson, M.A. (Intelligence Department, N.S.W.); Mr. R. Mackay (Public Works Department, N.S.W.); Mr. D. J. Gordon of Adelaide, S.A.; Mr. D. J. Mahony and Mr. A. S. Kenyon. Especially do I wish to record my indebtedness to Dr. A. J. Herbertson, Professor of Geography in the University of Oxford; and to the Yearbooks of Mr. G. H. Knibbs.

G. T.

Emmanuel College, Cambridge,
May, 1910.

PREFACE TO THIRD REVISED EDITION

In 1907 were given—what I believe to be—the first Australian University lectures on Economic Geography. As a result of this course the first edition of this book was published in 1911, and I first saw it in print in Antarctica in 1912.

A second issue in 1912, and a revised edition in 1915, enabled me to correct misprints, and to add a few maps and footnotes. Our knowledge of economic physiography has progressed so greatly in the last ten years that it is necessary to modify certain portions and greatly enlarge other portions of the book. I have, therefore, rewritten the chapters on Climate, Rainfall, and Environment; and added a new chapter on Climatic control.

Since the book was written in 1907 many notable events have occurred. The location of the Federal Capital, 1908; the visit of the Scottish Agricultural Commission, 1910; the transfer of Northern Territory, 1911; the Transcontinental Railway (1912 to 1917); the visit of the British Association, 1914; the European War, 1914; the Burrinjuck Irrigation scheme, 1914; the Hydro-Electric scheme in Tasmania . . . each of these has had its effect on our geographical development.

It is gratifying to note a change in public opinion during the past ten years as regards our economic resources. No longer are our Tropics referred to as the richest areas in the continent. The climatic disabilities of our northern agricultural lands are being recognized and studied, instead of being totally ignored. There are even some advanced thinkers who are doubting whether the centre of Australia is a promising pastoral region!

I trust that teachers of geography will realize that lists of mountains (many of which are mere edges of plateaux) and of rivers, bays, and capes (which have no human importance in the greater part of Australia) are of very little value in the study. Let us rather follow Francis Bacon's rule, 'True knowledge involves the study of Causes' (*Scire vere est per causas scire*).

It is a matter of regret that hitherto none of the Australian Universities has been able to devote much attention to economic physiography. There is little doubt that the 'strategists' in the 'peaceful penetration' campaign of the enemy before the war were the sixty-five professors who lectured in geography and meteorology in Germany and Austria.

G. T.

MELBOURNE,
May, 1918.

CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

In considering the industrial development of any area, there would seem to be **three stages** of growth in the progress of geographical knowledge.

(1) The first stage is the **exploration** and **preliminary mapping** of the continent. A glance at a series of maps, such as those of Australia shown in Fig. 2, shows the area of unexplored land (here marked in black) shrinking year by year, until little or none remains. In the case of Australia isolated patches appear in Western Australia near the boundary of South Australia, crossed by the trails of the prospector and squatter in every direction. Although this lately explored area is in general a waterless region, yet near the more elevated tracts there are many acres of land suitable for pasturage. Present day explorations often aim at obtaining **practicable stock routes** to these better favoured regions, such as the MacDonnell Ranges, while Government expeditions endeavour to open up feasible routes between isolated settlements, such as between Oodnadatta and Coolgardie, or Kimberley and Coolgardie.

As an example of such an expedition, take the arduous journey of Ernest Giles during 1875–6, when, starting from Port Augusta in South Australia, he crossed the Great Victoria Desert, passed just north of the site of Kalgoorlie and reached Perth. After a few weeks' rest, he returned eastward by way of Gibson's Desert, on a track 400 miles north of his previous journey, and reached the South Australian settlements again, fifteen months after his departure. To quote the *Year Book of Western Australia*, 'Giles was now able to thoroughly substantiate the views of those explorers and geographers who had described the *greater part of the interior of Australia* as a sandy desert, unfit for settlement.' Yet thirty years later flourishing towns exist in this desert, while Giles's route has been traversed by a solitary miner pushing a barrow before him! So much for the first stage.

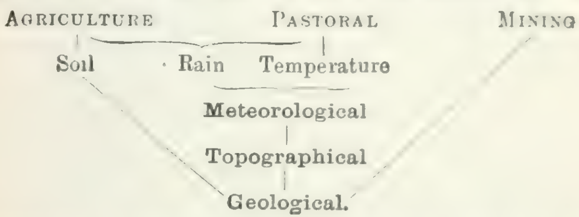
(2) The second phase in the development of geographical knowledge consists in the careful **accumulation of statistics** chiefly by government departments—so that the secondary mapping of the several states is possible as far as regards railway routes, land occupation, geological, agricultural, and meteorological data. This necessarily follows the first phase sometimes a long way behind it. The smaller and more thickly peopled states, especially Victoria and New South Wales, are very well supplied with such maps. The larger states whose resources are not yet fully known are rapidly filling in the blanks in their statistics.

(3) It is now possible to proceed to the third stage in the development of a country's economic geography, in which the **data previously collected are examined as a whole** from the geographical point of view and the broader features correlated. Such has been the work of Mackinder, Davis, and others in the older countries of the World, and in the succeeding chapters an attempt has been made to apply briefly, and for many reasons, inadequately, the methods so admirably employed in Britain, America, and elsewhere.

There would seem to be a definite sequence in this investigation. The physical factors controlling the industrial life of any country may be classed under three heads, **topographical, meteorological,** and **geological** respectively, and of these the last is not least. In a new country such as that under consideration, by far the greater proportion of the workers is directly concerned with pastoral, mining, and agricultural industries. Manufactures and transport do not bulk largely, as in the older centres, as means of livelihood.

It is unnecessary to emphasize the obvious relation between mining and geology, or between soils and geology. The local distribution of rainfall is closely bound up with topographical features, while these latter, as will be shown, are dependent on the arrangement of the geological formations.

The following diagram will perhaps serve to illustrate in a very broad sense the relation of these three main industries to the controlling factors mentioned above:



This diagram, while not to be taken too literally, indicates that the **distribution of sheep and cattle** is almost wholly a question of varying climate. **Agriculture** depends chiefly on soil and rainfall—since, given these, crops ranging from tropical to temperate can be grown in one area or another of the continent.

It also explains the order of treatment in the following chapters. The subject is dealt with in two parts, the first part being of a more general geographical character, and the second dealing with special industries in regard to their distribution, importance, physical control, &c.

In Part I, after a preliminary account of the discovery, **exploration**, and exploitation of Australia, the broad **geological features** are described with special reference to the **topography** of the continent. Then follows a discussion of the relation of contour and climate, with special reference to the question of **rainfall.** The systematic position of the **Australian climates,** among Herbertson's main types—a most important subject in connexion with the future development of industries—is treated next. The factors controlling tropical settlement are also studied briefly. The continent is next divided into **five geographical units,** and each of these (usually subdivided) is described in some detail with the aid of diagrams. By this means it is hoped that a clear idea of the inter-relation of the varied industries and their dependence on similar physical controls in any one region will be arrived at. The last section of Part I shows in greater detail the correlation of the geology and meteorology with the industrial development of one state—that of New South Wales.

In Part II, which deals with the great industries separately, the order is in the main determined by their relative importance. The **Wool Industry,** since wool constitutes one-third of the total exports of the Commonwealth, is described in the greater part of the first section: and closely allied to it are the **Cattle** and **Frozen Meat** industries. **Artesian water**—the use of which is almost wholly confined to pastoral areas—naturally finds a place in this section. The second section is concerned with the chief agricultural industry—that of **wheat. Irrigation** is a factor of great and increasing importance in the Wheat Belt and occupies a large part of this section. Section III deals firstly with **metal mining,** in which I have chosen to describe several of the most important ore deposits at some length rather than give inadequate descriptions of all the many important mines; and, secondly, with **coal-mining.** In Section IV four of the typical industries of Australia are considered—**Timber, Sugar, Pearl-Shell-**

ing, and **Fisheries,** both freshwater and marine. Several of the lesser industries, such as wine-growing, are described briefly in the general geographical sections of Part I, and are therefore not specially mentioned in Part II. The subject of **internal communication,** whether by water or rail, is of great importance and is discussed in the next section. The last section of the book deals with **future settlement** in Australia, and is an endeavour to show in what areas industrial growth is likely to occur.

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PART I

PHYSIOGRAPHIC ASPECTS

SECTION I. EXPLORATION AND EXPLOITATION

CHAPTER I

THE DISCOVERY, DIMENSIONS, EXPLORATION, AND EXPLOITATION OF AUSTRALIA

All who have studied the history of geographical discovery must have been struck with the wonderful voyages which took place during the last twenty years of the fifteenth century. The ocean paths to the West and to the East were traversed for the first time, and two continents, America and Africa, were represented on World maps. In 1487 **Diaz** reached the Great Fish River (near Port Elizabeth in Cape Colony); in 1492 **Columbus** reached the West Indies.

It is not too much to say that a great factor—possibly the greatest—hindering earlier exploration by Western peoples was the **vast desert area**, not only extending from Cape Bojador to Cape Verde,[1] along the Atlantic, but occupying the shores of the Red Sea and reaching across Arabia (see Fig. 14). When the fertile lands (the 'Verdant' cape of the Portuguese) to the south of this barrier were discovered, exploration pushed on with rapid strides. It is of interest to note that a similar geographical factor tended to retard the exploitation of Australia for three hundred years. The NW. portion, being the nearest to Europe, was naturally that first discovered, and this is also largely a desert region. Even to-day the whole

[1] These capes lie north and south of the Sahara respectively.

western half of the continent contains only seven per cent. of the population.

Probably most people have the idea that **Cook** discovered Australia—and this is true as far as regards its chief **economic regions**—but the greater portion of its coast line had been accurately mapped long before 1770. According to some writers the same marvellous twenty years (1480–1500) of the fifteenth century first brought the third and last unknown continent to the knowledge of Europeans.

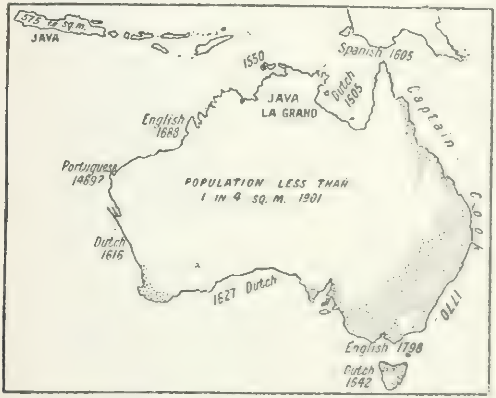

FIG. 1. Sketch-map showing the Progress of the Discovery of the Coasts; also the Relation of the fertile Dutch Indies to the barren NW. of Australia. Dotted areas in Australia over one person to 4 sq miles (1901). In 1910 these areas had increased, chiefly along the railways of W.A. and Queensland.

Collingridge—who has investigated this question most fully—is of the opinion that seven years before Columbus set sail for America the west coast of Australia was indicated on charts. There is little doubt that the Arabs and other traders to the East Indies would know of the huge island to the south, and a map in the British Museum, dated 1489, shows a coast line in the latitude of Cape Colony and south of Malacca which is not present on earlier maps based on the travels of Marco Polo (A.D. 1300).

Though this date of discovery, 1489, is based on somewhat slender evidence, there seems little doubt that a portion of the northern coast had been thoroughly explored by Europeans by 1536. Every bay and cape is named on the famous **Dauphin map** of this date. But Java la Grande—as it was called—offers few inducements to white settlement compared with other regions of Australia. In 1913 there were 2,143 Europeans, of whom only about a dozen were farmers, in Northern Territory, though Australia had long celebrated her centenary of settlement.

The **Dutch** supremacy in the East Indies dates from early in the seventeenth century, and in 1605 they explored the Gulf of Carpentaria and later (1616) the arid west coast near Sharks' Bay. In 1642 the first great voyage of Australian discovery—that of **Tasman**—resulted in the charting of the south coast. Had the Dutch maintained their supremacy in the East probably they would have founded settlements in the temperate lands they first discovered.

The English, led by **Captain Cook**, were the first to investigate the eastern coast of Australia. In April, 1770, Cook, the second great Australian voyager, sighted the mainland near Cape Howe and made a careful survey as far north as Cooktown. When **Flinders and Bass** discovered in 1798 that Tasmania was an island, the knowledge of the coastal outline was practically completed.

It is interesting to note that some sixty-four of the eighty largest towns in Australia (i.e. those with more than 3,000 inhabitants) lie in the region whose coasts were discovered by the English.

This fact is indicated on the sketch-map and explains the main reason why neither the Portuguese, Spanish, nor Dutch made settlements on the Southern Continent. Moreover, these early navigators were traders rather than colonizers; though had the black occupants of the continent had even a rudimentary knowledge of trade and industry, probably their products would have found a market, and led to the founding of trading stations such as soon studded the East Indies.

After Cook's survey it was possible to gauge the size of the new continent, and some facts bearing on this question may now be given. Australia, including Tasmania has an **area of 2,974,600 square miles.** It is interesting to note how similar is the area of the United States of America (2,970,230) which is 99·8 % of that of the southern continent. Australia constitutes more than one quarter of the British Empire, and is nearly **twenty-five times as large as the United Kingdom.** 'It is this great size, taken together with the fact of the limited population (4,119,481 in December, 1906), that gives to the problems of Australian development their unique character.'[1] It extends through 33° of latitude, which is equal to a journey from London to Cape Verde, so that it is obvious that one cannot strictly speak of the *climate* of Australia, for it **has many climates,** ranging from a tropical climate akin to that of the Sudan to a cool temperature like that of Scotland.

In position it is **more isolated** than any other large land mass. Taking as a standard of length the distance from London to Algiers (about a thousand miles), the journey from Perth to Colombo is more than three times this unit ; and the same huge distance lies between Hong Kong and Thursday Island in the north of Queensland. Indeed, Java is the only large civilized area which is within a thousand miles of any portion of Australia. But Australia itself is a country of vast distances. The two capitals Perth and Adelaide are some 1,600 miles apart.

[1] G. H. Knibbs, *Commonwealth Year Book*, 1908, p. 57.

while to reach Broken Hill—the third town in New South Wales—from the capital Sydney, a railway journey of some 1,400 miles (via Melbourne and Adelaide) is necessary.

The exploration of the Interior of Australia until 1860 was carried out almost wholly with an eye to the main chance, and a brief survey of the order in which the various areas were occupied forms a good introduction to the succeeding chapters.

In 1788 **Phillip** landed at Botany Bay from the 'First Fleet', but soon discovered the immeasurably superior site of Port Jackson, some eight miles to the north. Till quite recently the northern and southern shores of **Botany Bay** remained almost deserted except for glue-works, boiling-down and wool-scouring plants, and other more or less unsavoury industries.

The earliest settlement, consisting largely of most unprofitable members, was subjected to many trials, and in the first year of the nineteenth century (1801) numbered only 5,547 persons. Agriculture did not thrive near Sydney in the sandy soil, and though good soil was found near Parramatta (15 miles to the west) the area to the east of the Blue Mountain Scarp was soon found to be too restricted for the multiplying flocks and herds of the settlers. Yet it was twenty-five years before **Blaxland's party** managed to climb the rugged slopes of the Blue Mountains, and found the ideal pastoral country at the head of the Macquarie. From this time (1813) the rise of a huge Pastoral Industry was assured, and exploration in Australia has largely consisted of 'treks' to find new pastures.

The early exploration of Australia is full of interest to the student of economics. The feeling that 'better lay beyond' was shared by every pioneer until 1873–6, when by the crossing of the unknown desert by Warburton, Forrest, and Giles, the limits of the possible pastoral areas of Australia could be determined with some accuracy.

Very early the explorers found that the rivers of the inland portion of New South Wales all seemed to flow

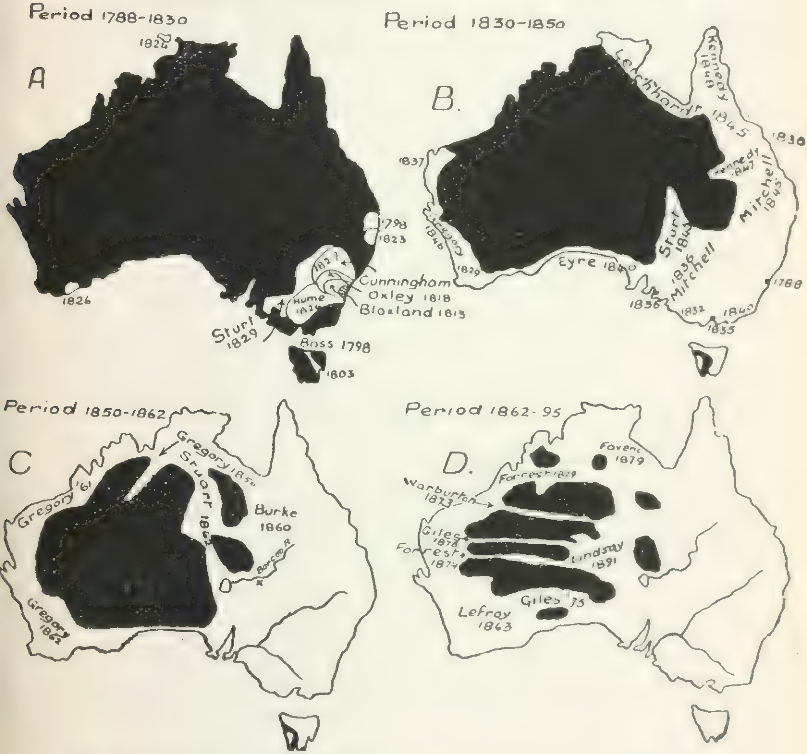

Fig. 2. Progress of the Exploration of the Interior of Australia.

towards the west, and therefore we find **Hume** hailing Lake George (near Goulburn, N.S.W.) as a portion of an inland sea, and **Mitchell** carrying boats over the Western Plains to navigate this hypothetical sea. In February, 1830, **Sturt** had found the Murray mouth and had commenced his attack on the desert which always baffled him, for he had penetrated but a little by 1845 (see Fig. 2 B). **Mitchell**, during this period, was more fortunate, and discovered the fertile Western Plains of Victoria and the good pastoral country in Southern Queensland. The unfortunate explorers **Leichhardt** and **Kennedy** opened up the north-east of Australia, though here, if the desert were absent, the blacks were more numerous and dangerous than in the south. **Eyre** and **Gregory** had explored the south and west, but except in the Perth-Albany area there was no incentive to any but a pastoral settlement, moreover here the desert approached much nearer to the coast.

1850 marks the close of an almost wholly pastoral Australia. True the **Burra mines** north of Adelaide yielded rich copper ore in 1844, but they were of little importance compared with the vast mineral output which followed the **gold discoveries** of 1851 in the Bathurst district (N.S.W.) and of 1852 around Ballarat in Victoria. Unlike the later metalliferous discoveries of Broken Hill and Coolgardie, these fields were developed in country which had been occupied by sheep stations for years, so that they had no direct effect on the exploration of Australia.

During the period 1856–62 the **Gregorys** found new pastoral areas all round the north and west of the Great Desert, while A. C. Gregory on the north penetrated to the desolation of spinifex[1] and sand in which Sturt's Creek loses itself (see Fig. 2 C).

In the seventies no less than five expeditions crossed the great desert. **Warburton** (1873), **J. Forrest** (1874); **Giles**, to the south (1875), returned through the centre in

[1] *Triodia irritans* or false spinifex is the prevailing herbage in the arid region.

1876, and **A. Forrest** across the north in 1879 (see map, Fig. 2 D). All found the same waterless region which is described in some detail in another section (pages 119–22).

In 1860 began a new phase in this exploration. **Stuart** from Adelaide and **Burke** and **Wills** from Melbourne were spurred onward very largely by the desire to be the first to cross Australia from South to North. They both succeeded, but while the costly and ill-managed expedition of Burke and Wills resulted in the death of the leaders near the Barcoo River (at x, Fig. 2 C), that led by Stuart was very successful and resulted in the discovery of fair pastoral land around the MacDonnell Ranges in the heart of the continent. Moreover his route formed a preliminary survey for the **overland telegraph** (completed in 1872) which extends 1,973 miles from Adelaide to Palmerston.

In 1883 gold was first discovered in Western Australia, in the Kimberley district, and the ensuing 'prospecting' resulted in the exploration of much new country. In 1892 the **Coolgardie fields** were found well within the desert country and several[1] prospecting expeditions (such as **Carnegie's,** 1896) have practically erased the unexplored patches from the map.

The **Horn expedition,** of a scientific character, to the MacDonnell Ranges in 1894 marks a new development (see p. 123), while **Calvert's** in 1896 (under Wells), though marred by the death of several members, was primarily undertaken to map the remaining unexplored regions.

In conclusion, let us glance at the history of the Industrial expansion of Australia during the last fifty years.

[1] The routes of some of these later expeditions are shown on the sketch-map of the Great Plateau Region, Fig. 27, p. 113. Mention should be made of Canning's stock route between Wiluna and Hall's Creek. Fifty permanent wells are now available for cattle travelling from Kimberley to the southern gold-fields.

In 1913 the **principal products** exported were approximately as follows:

		£			£
1.	Wool (exports)	26,000,000	9.	Tallow	1,900,000
2.	Wheat (total)	13,300,000	10.	Sheep skins	1,500,000
3.	Gold (total)	10,500,000	11.	Tin	1,200,000
4.	Butter (exports)	4,600,000[1]	12.	Timber	1,000,000
5.	Coal (total)	3,900,000	13.	Hides	600,000
6.	Silver-lead	3,000,000	14.	Rabbits (export)	400,000
7.	Frozen meat	2,700,000	15.	Pearl shell	300,000
8.	Copper	2,500,000	16.	Wine	150,000

In 1788 Captain Phillip brought out **twenty-nine sheep** and six cattle, and these had increased (with fresh imports by McArthur) to sixteen million sheep and two million cattle in 1850. By this time (compare Fig. 2 B with Fig. 33) the best *sheep* country had been occupied and comparatively few flocks now range in areas discovered since that date; though the best *cattle* districts lie in the more northern belt explored from 1850 to 1860.

Very early in the continent's history the value of the **coal** was appreciated. It was discovered both north and south of Sydney (near Newcastle and Bulli) in 1797, and in 1850 the coal raised was worth £23,000. In ten years the value had jumped up to £226,000, of which two-thirds was received for exported material.

Wheat-growing and **copper-mining** became important in South Australia about 1842; and for years it was renowned for them. Now it is only the third among the copper-producing states. Queensland is first. The erstwhile gold-mine of Mt. Morgan is the most important source, and Mt. Lyell in Tasmania (1886) is another.[2] In wheat also, New South Wales and Victoria with their greater area of wheat lands have outstripped South Australia. It was not till 1898 that New South Wales

[1] Slightly more is consumed in Australia.
[2] In 1913 Copper produced in Queensland, £1,660,000; N.S. Wales, £599,000; S. Australia, £489,000; Tasmania, £376,000.

exported wheat, while in 1903 a large import was necessary owing to the drought.

In 1851 Hargreaves discovered gold near Bathurst, N.S.W., and gold areas have gradually been exploited in districts all round the Main Artesian and Murray Basins, whose sediments are too recently deposited to be auriferous.

During the fifties and sixties the south-east highlands

FIG. 3. Dates of Gold Discovery. Non-auriferous formations dotted.

were extensively prospected from Ballarat to Gladstone in Queensland. In the early seventies gold was found in Northern Territory, and at Palmer River and Charters Towers in North Queensland. The rich 'deep leads' of Gulgong, near Bathurst, were discovered in 1871. During the eighties Western Australia was found to have large areas of auriferous country, which were traced into the arid interior from 1890 to 1898. Two isolated gold-fields in the South Australian desert (**Tarcoola,** 1893, and **Arltunga,** 1902) show that there is no reason to despair of the discoveries of further 'Kalgoorlies'.

It is not only in the desert that rich finds are being made. Wyalong and Mt. Boppy (near Cobar), two of the richest fields in New South Wales, date from the nineties, while Poseidon (1906) seems to show that all the 'Welcome Nuggets' have not yet been gathered from the Ballarat area.

The next important product on the list of exports is Silver-lead. **Broken Hill** (1911) contributes about 85 per cent. and Mt. Zeehan (Tasmania) about 8 per cent. of the total for Australia, so that these two centres account for more than 90 per cent. of the whole. Lead ores usually contain considerable quantities of silver, which forms a very valuable proportion of the output.

The fourth in order of importance of the metals exported is tin. One of the richest mines in the world is situated near **Mt. Bischoff** in the jungles of North-West Tasmania and was discovered in 1871. It is still producing much tin and gives Tasmania a slight advantage over Queensland. Tin-mining on the mainland dates from 1872, when rich mines were discovered near the New South Wales border at Inverell and in Queensland, near Warwick. Later deposits have been found near Beechworth (Victoria), at Chillagoe (near Cairns, Queensland, 1879), and in West Australia (about 1890) at Greenbushes and Pilbarra.[1]

In the last twenty years three thriving industries—which were not dreamt of in the earlier days of industrial occupation—have become of great importance. **Butter** was first exported from New South Wales in 1890, and in

[1] These mining fields are shown on the sketch-maps of the chief geographical regions, Figs. 18–27 and on Fig. 49.

1913 Australia exported butter to the value of £3,565,000, Victoria being the chief producer. **Frozen meat** (mutton and beef) was shipped to England in 1881 from New South Wales, and is now seventh on the list of exports. Finally, a credit side is placed to the account of the **rabbits.** In New South Wales alone rabbit-proof fencing to the extent of 45,000 miles has been erected, costing £2,500,000, but it would seem that in the course of time the trade in frozen rabbits, &c., which was worth £500,000 in 1906, will to some extent counterbalance the damage done by them.

SECTION II. PHYSICAL CONDITIONS OF AUSTRALIA

CHAPTER II

THE RELATION OF TOPOGRAPHY TO GEOLOGY

AUSTRALIA is somewhat oval in shape, with two well-defined breaks in the outline, the Gulf of Carpentaria on the north, and the Australian Bight on the south. A diagram showing approximately the main contours of Australia is given in Fig. 4, and shows that the continent is strikingly devoid of strong contrast. Three-quarters of the land-mass lies between the 600 and 1,500-feet contours in the form of a **huge plateau.** Of the remainder there is a **low-lying area** comprising the Murray and Lake Eyre Basins, partly separated by the Flinders and Barrier Ranges; and secondly, a **fringe of land with an elevation of two or three thousand feet** culminating in 7,000 feet at Mt. Kosciusko—extending through Victoria, Eastern New South Wales, and Eastern Queensland. Isolated elevated areas, such as the MacDonnell and Musgrave Ranges in Central Australia, and others in Ashburton, Kimberley, and near Albany, reach three or four thousand feet but are usually of the nature of bulges on the surface of the plateau rather than true mountain ranges.

We can readily distinguish the five main topographic divisions of the continent. There is the **elevated Cordillera** extending from Cape York along the east coast to the Murray Mouth; the **huge Western Plateau**; and the low-lying basin of the **Murray-Darling system** separated from the **Lake Eyre Basin** by the long ridge of the **Flinders Range**.[1]

Can these be correlated with the geological structure of Australia? Undoubtedly.

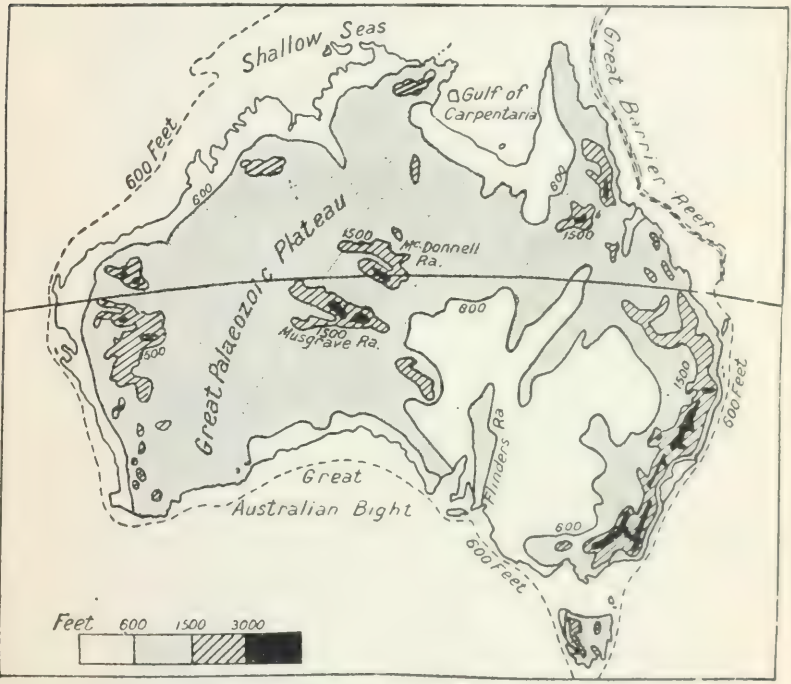

FIG. 4. Contour Map of Australia.

In Australia, as in other parts of the World, the periods at which rocks were deposited are determined by their fossil contents. For the purposes of this section only the three main terms, tertiary (or Cainozoic), secondary (or Mesozoic), and primary (or Palaeozoic) will need to be remembered.

[1] These five divisions are defined and sketched in Chapters VII–XI

Rocks deposited during the last few million years contain fossils on the whole closely resembling living forms. They have been termed **tertiary** sediments. Passing back in geological time we get a series of rocks characterized by remains of huge reptiles and other animals to which only a few rare living genera are in any way akin. These rocks belong to the **secondary** age. Earlier again we have an immense succession of strata stretching back through millions of years to the dawn of life. These are known as rocks of the **primary** age.[1]

In Fig. 5 an attempt is made to show the broader geological features of Australia. No complete map has been issued for the very sufficient reason that Central Australia is largely a 'terra incognita' as far as its geology is concerned.

Undoubtedly the dominant feature is the vast area of *metamorphic* rocks in the west. These are highly altered rocks, originally both sedimentary and eruptive, which have lost all, or almost all, semblance of their original form through crushing, folding, and chemical action. Such rocks as *schists*, gneisses, and altered slates, together with granites and basic rocks—termed *greenstones* for want of a better name—are common. This **solid 'massif'** has endured from the dawn of life, resisting later folding, and has been gradually worn down to a huge plateau of

[1] The generally accepted subdivisions of these are:

		No. on Map 5.
Tertiary or *Cainozoic*	(newest)	7 and 8
Secondary or *Mesozoic*	Cretaceous	6
	Jurassic	
	Triassic	
Primary or *Palaeozoic*	Permian	5
	Carboniferous	4
	Devonian	4
	Silurian	3
	Cambrian	2
Eruptive or Igneous	Granites, &c.	
Metamorphic or Altered	Schists, &c. (oldest)	1

some 1,500 feet elevation. The remarkably rich gold deposits of Western Australia occur in these rocks. Their geology will be briefly discussed later. This ancient area is shown by the wavy lines and crosses (1) in Fig. 5. Fringing it are areas of newer rocks deposited in bygone gulfs and then elevated above sea-level.

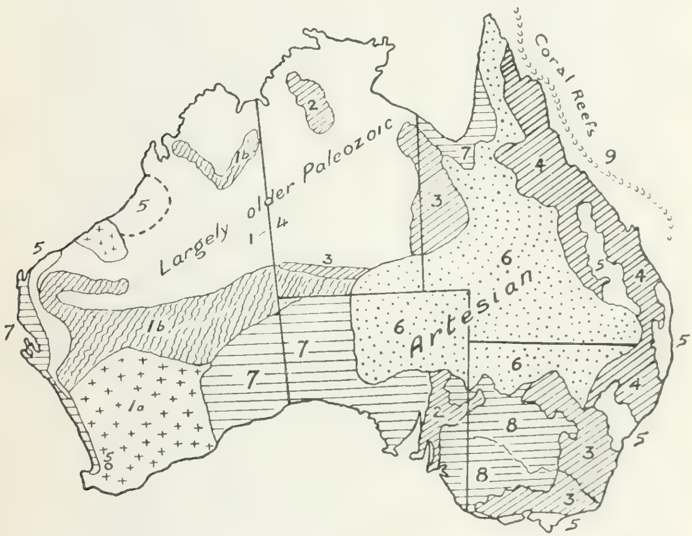

FIG. 5. Geological Sketch-map of Australia. 1 = Gneisses and Granites (Archean); 2 = Cambrian Sediments; 3 = Silurian Slates, &c.; 4 = Devonian and Carboniferous; 5 = Coal-measures (Permian, &c.); 6 = Cretaceous Artesian Basin; 7, 8 = Tertiary; 9 = Pleistocene Coral Limestone. (All generalized.)

Secondly, we come to rocks (2, Fig. 5) which are immeasurably old, but containing fossils representing the **earliest forms of animal life.** A large area occurs in South Australia, constituting the Flinders Range. It may extend to New South Wales. These rocks are surrounded on all sides by sediments of a comparatively recent date, geologically speaking (see 6, 7, and 8, Fig. 5). The former sediments (2) contain numerous copper mines (Moonta, Burra, &c.) and are thought by some geologists to extend to Broken Hill, and thus they contain the largest Australian ore deposit.

Thirdly, a large series of slates and sandstones (3) is most fully developed in the south-east of the continent, but found also in smaller areas in Queensland. They may be classed as middle palaeozoic (Silurian and Devonian). They have been subjected to **great folding forces,** which have crumpled the earth's crust, and have buckled them into ridges and troughs.

Fourthly, somewhat later there were deposited huge masses of rock which have been similarly folded in Queensland (4) and New South Wales.

These buckled and warped rocks have been in touch with hot underground waters. This explains the prevalence of valuable **metalliferous reefs** such as the gold-bearing Saddle Reefs of Bendigo, the auriferous reefs of Ballarat, and the copper deposits of Cobar. In fact, almost all the reefs of Eastern Australia occur in rocks of palaeozoic age.

The *fifth* group of rocks (5) are those bearing valuable coal-seams and hence known as **coal-measures.** It is sufficient to state here—as the matter will be discussed in a later section—that the coal-measures lie in huge troughs formed by the folding or erosion of the earlier palaeozoic rocks. Though of several ages, all the best seams belong either to the late palaeozoic (permo-carboniferous) or early mesozoic (triassic).

The *sixth* area is the huge **Artesian Basin** (6), extending from the Gulf of Carpentaria almost to the South Australian gulfs. It is by far the most extensive formation which has been adequately mapped in Australia and is of great economic importance. In its relation to stock routes and irrigation it forms the subject of a separate section.

In the *seventh* section are grouped the tertiary and recent rocks. They comprise large areas of sediments due to the action of existing rivers, as in the Gulf Country in Queensland, and to the latest movements of elevation in Australia, which have raised marine sediments into dry land, especially around the Murray Mouth (see Fig. 23). Other areas of new land—speaking in a geological sense—are found in Nullarbor Plains (near the Australian Bight).

Lastly, one of the most interesting areas of recent land-growth in the World may be mentioned—the coral rock gradually spreading over the sinking Queensland continental shelf. This huge deposit of limestone extends for 1,250 miles and has an average width of 35 miles along that distance. Many important industries have arisen in connexion with this formation, such as pearl-shelling, bêche-de-mer fishery, turtle-fishing, &c. It is also of great commercial importance as constituting what may be termed a marine 'Grand Canal' largely used in Australian trade with India and the Far East.

Having thus summarized the broad topographical and geological features, an interesting correlation expressed in the table on pages 32 and 33 may be made.

From the following table it will be seen how closely the topographical divisions coincide with the geological structure of the continent. Traversing Australia from east to west in Fig. 5, we see that the highest land consists of palaeozoic rocks (3)—by no means, however, the oldest sediments represented—buttressed by granite, as at Kosciusko and New England. As soon as the low-lying belt, extending from the Gulf of Carpentaria to the Murray Mouth, is reached, a very much newer

formation—late mesozoic or tertiary (8) is encountered. Crossing the southern portion of this lowland we reach the very ancient limestones (2) and slates of the Flinders Range which are of Cambrian (i. e. oldest palaeozoic) age.

The west of the continent consists very largely of altered rocks (1) which seem to have formed a land-mass since very early times, and in which few fossiliferous beds occur.

Group.	*Geological Formation.*	*Topography.*	*Climate.*	*Economic Value.*
A.	*Metamorphic Rocks* of West A. and N. Territory; schists and slates, probably pre-Cambrian in age. Granites and greenstones.	A Plateau of some 1,000 feet elevation. No high mountains and no rivers except along the coast.	Situated in the Trade Winds area along the tropic of Capricorn. Hence very dry, with few important ranges to condense erratic cyclonic rain clouds.	Largely desert, little agricultural value. Many valuable mineral deposits, e.g. Coolgardie, Murchison, and Kimberley Gold-fields.
B.	*Older Primary Rocks.* Cambrian(2), silurian, (3), devonian, carboniferous (4). Usually crumpled, faulted, and penetrated by intrusive rocks. N.B. Probably the main folding occurred in carboniferous time.	Form the backbone of Eastern Australia ; Flinders Range, S. A.—Victorian Highlands, Snowy Mountains, and the Great Divide in general. Their flanks are covered by later sediments.	Favourably situated to condense the moisture of sea-breezes, cyclones, SE. trades and other winds. Hence the rainfall is heaviest in this belt.	The chief metalliferous deposits, except those noted above, occur in these crumpled strata. In the valleys and coastal regions of this group the main population of Australia dwells.

They apparently are the worn-down bases of a much greater elevation, but their geology is not yet worked out. Around the Australian Bight is an area of late sediment (7), provisionally classed as Tertiary, and on the west coast there is a fringe of palaeozoic (5) and later sediments, somewhat resembling—but not so extensive as—those on the east.

Group.	*Geological Formation.*	*Topography.*	*Climate.*	*Economic Value.*
C.	*Coal-bearing strata* (chiefly permo-carboniferous and triassic) (5). Sandstones and shales with numerous coal seams. Occupy basins (geosynclines) in the preceding rocks.	Forming an integral part of Section B. In some cases the softer coal measures have been eroded to a greater extent than the rocks enclosing the basin, as in the Hunter Valley, N.S.W.	Too small in area to affect the main features.	The manufacturing industries, more important potentially than actually at present, will develop along the great coal basin of Eastern Australia.
D.	*Newer sediments* which, in the main, have not been folded or crumpled. Includes the great artesian basin and Tertiary deposits of Eastern Australia.	The Great Central Plain of Australia. Low-lying country, extending from the Gulf of Carpentaria to the Great Australian Bight. Few large rivers, nearly dry in summer.	Eastern portion dry, but with a fair rainfall owing to proximity to mountains and the coast. Western portion merging into desert.	The east is the great grazing country of Australia. The west is watered sparsely by artesian wells. Opals are practically the only mineral wealth, except alluvials associated with palaeozoic rocks.

CHAPTER III

FACTORS GOVERNING THE CLIMATES OF THE SOUTHERN HEMISPHERE

For an intelligent grasp of the Economic Geography of a large area like Australia it is essential to study carefully the physical conditions which control the life and industry of the continent. Of these physical controls those of climate and geology are of especial importance. Quoting a well-known writer, 'Large commercial relations can exist only between large populations, and these are found in those temperate or tropical regions that are best adapted to support human life. Unfavourable climates have small populations and little commerce ; no large industries except mining can thrive where climate does not permit large agriculture or animal-raising.'

Hence the problem of commercial supply is based very largely on a study of climatic conditions, and it will be our endeavour to explain in some degree the little-known and rather vexed question of the factors governing the climates of Australia.

In the first place it will readily be recognized that an area of land extending from 10° to 45° of latitude will embrace a **variety of climates.** Indeed Port Darwin in the extreme north has a hot, moist climate like that of Trinidad (**West Indies**), while the climate of Tasmania has often been compared to that of **England.** To understand clearly, therefore, the various conditions governing this vast area it is well to study the meteorology of the belts of the southern hemisphere on the equatorial side of 45° S.

We may begin by deducing in logical sequence, *first*, what would be the climatic phenomena on a *stationary* uniform globe enclosed in a shell of air; *secondly*, the effect of the rotation of the Earth from west to east on such a system; *thirdly*, the seasonal changes brought about by the revolution of the Earth round the Sun; and *fourthly*, the variations arising from the somewhat complex distribution of land and sea on our globe.

One might reasonably expect to observe the following phenomena on a *stationary globe*. At the equator the atmospheric layer is heated strongly and expands. It is therefore lighter than a corresponding bulk of the colder air beyond, and the latter flows in along the surface from north and south. The warm air is therefore displaced upwards, forming a belt of relatively low pressure at the surface all along the equatorial belt. From this belt the upper portions of relatively high pressure continually stream polewards and thus the primary circulation of the air arises; a surface wind blowing *to* the equator, and an elevated wind blowing *from* the equator (see Fig. 6).

At the South Pole there is probably a great chilling and descent of the overhead air—whence it would flow back to the equator along the surface as a south wind.

But an even greater factor in the control of the circulation is the rotation of the globe, which has a profound effect on this comparatively simple circulation. We know that each point on the equator is moving from west to east with a velocity approaching eighteen miles a minute The velocity decreases towards the poles, where it is zero. Without entering deeply into the dynamics of the question, one can readily understand that there will be a considerable distortion impressed on the path of any object moving along a meridian.

This deflexion due to the Earth's rotation has been mathematically investigated by **Ferrel** and others, who deduce the general law that **all bodies (including air) moving in any direction in the southern hemisphere have a tendency to be deflected to the left.**

We must therefore modify these wind directions so that the more correct paths are as shown in Fig. 6. Thus the surface wind near the equator becomes the south-east **Trade Wind**, and the surface wind from the Pole becomes the **South-east Blizzard.** The upper return-current from the equator changes from a north wind to a north-west

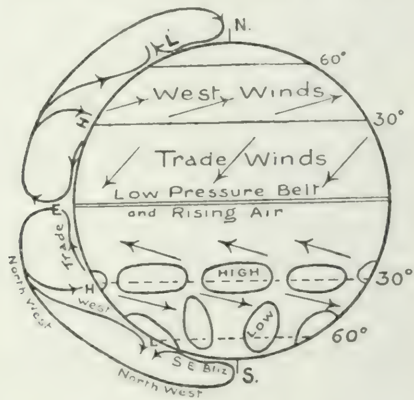

FIG. 6. Chief features of the Circulation on a Rotating Globe. On the left the winds are shown in elevation.

wind, and ultimately becomes a **west wind** when it reaches temperate regions.[1]

The chief effect of the Earth's rotation is to produce belts of high and low pressure in temperate regions. We

[1] A simple dynamical example may make this clearer. A stone thrown in a southerly direction from an east-bound express train is deflected with respect to the (relatively slow-moving) earth and can be compared to the air in the southern anti-trade winds. The stone, to an onlooker, would appear to come from the north-west. In a similar manner the original return-trade is converted into a westerly wind.

can best understand this by considering a simple dynamical experiment. If we place a bowl of water on the centre of a rapidly rotating table, we find that the water moves away from the centre of rotation, and is piled up at the edge of the bowl. In something the same way the air is kept away from the South Pole and heaped up along latitude 35° S.

Hence there is a low pressure belt at the equator due to the rising of heated air. There is a belt of high

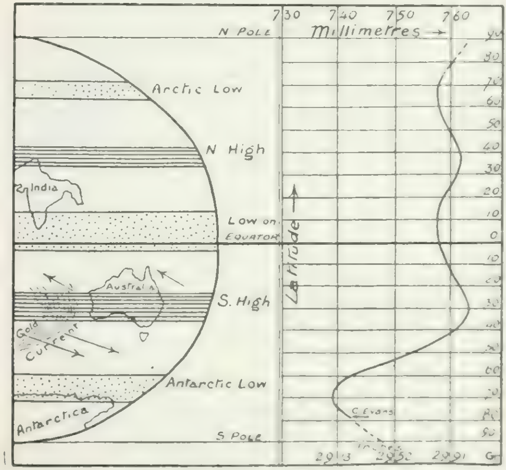

Fig. 7. Actual Pressure Belts in relation to Australia and the World. On the right is a graph relating Pressure and Latitude (based on Hann). The cold current producing the 'centre of action' off Western Australia is shown.

pressure at latitude 35°, and a belt of low pressure at latitude 70° S. [The very cold area at the South Pole (which is an ice-covered plateau 10,000 feet high) causes a slight high pressure which we need not consider] (see Fig. 7).

Before considering the *effect* of the distribution of land and sea on the atmospheric circulation of the southern hemisphere, it will obviously be an advantage if we can discern any 'design' in the relative positions of land and sea. A reference to Fig. 8 will show that there is some such design, which Professor J. W. Gregory has termed the **Antipodal arrangement.**

It will be seen that the circular Arctic sea is opposite the circular Antarctic continent, and that the three great oceans (Atlantic, Indian, and Pacific) approximately alter-

FIG. 8. The Symmetrical Earth-plan. (Based on Lowthian-Green and others.)

nate with the continental masses of Eur-Africa, Asia-Australia, and America.

Whatever be the value of this deduction with regard to the origin of the Earth's surface-features [1] there is no doubt that it is very helpful in discussing various aspects of

[1] This subject and its bearing on the "Plan of the Earth and its Causes' is discussed by J. W. Gregory in the *Geographical Journal*, 1899, vol. xiii, p. 225.

Austral Meteorology, such as the eddies in the Great Belt of Southern Anticyclones (see page 43) or the correlation of Climatic Regions (page 59). Moreover, as the southern hemisphere contains the *oceanic* belt in this Antipodal arrangement, it follows that the lands capable of commercial development are much smaller south of the equator than in the northern hemisphere.

Dividing the Earth's surface into isothermal zones according to Supan's plan—where 32° F. and 68° F. for the

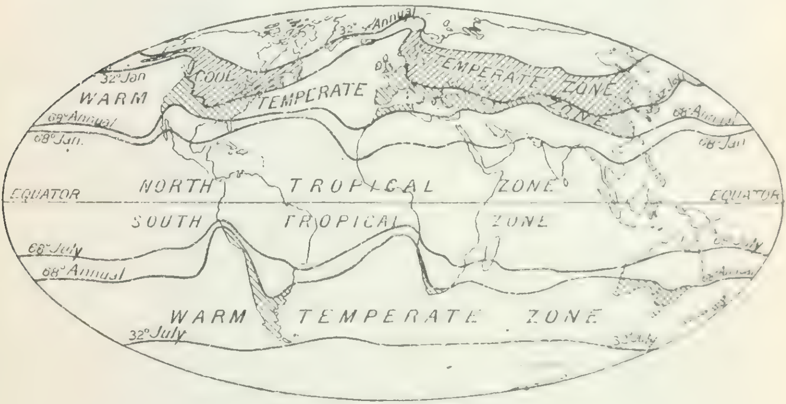

Fig. 9. Thermal Zones.

coldest month, and mean annual temperature, respectively, are chosen as the significant temperatures (see Fig. 9) we get five zones on each side of the equator. The following table shows approximately the land-areas in square miles (from Blackie's Atlas):

No.	*Zone.*	*Northern Lands.*	*Southern Lands.*
1.	Frigid	7 million sq. m.	None of economic importance.
2.	Cool temperate	10 million ,,	,,
3.	Warm temperate	$4\frac{1}{2}$ million ,,	2 million sq. m.
4.	Semi-tropical	8 million ,,	4 million ,,
5.	Tropical	$7\frac{1}{2}$ million ,,	6 million ,,

The zones 2 and 3 may fairly be said to contain all the great manufacturing interests in the world, and to be the most favourable for white colonization. In the northern hemisphere these comprise nearly fifteen million square miles, in the southern hemisphere only two million lie within the favoured region.

Having now emphasized the peninsular or insular character of the southern lands, the discussion of their meteorology may be resumed.

The winds of the southern hemisphere obey simpler laws of circulation than do those of the northern hemisphere. This is due to the fact that the southern hemisphere offers much less irregularity of surface, consisting for the most part of large ocean areas.

Want of space forbids more than a brief account of the way in which the distribution of land and water modifies the atmospheric conditions of the surface of the southern hemisphere, and more particularly of Australia.

The enormous land-bulk of central Asia exerts a strong influence on the northern portion of Australia. During July (the northern summer) the hot air rising over Southern and Eastern Asia draws in surface supplies (monsoons) from the south and undoubtedly reinforces the south-east trades in Northern Australia (see Fig. 14).

During the four months of the southern summer the south-east trade is replaced by variable winds in this region. During December (the southern summer) the north-west of Australia becomes strongly heated (see Fig. 15 B) and the cooler air from the north flows in (being heavier than that in Australia), and may be imagined as displacing the lighter medium, much as mercury displaces water. Actually no great bodily transfer takes place, the temperature-change being effected largely by conduction and by convection currents.[1]

[1] In *convection* the atmosphere is warmed by currents of air, in *conduction* by contact with the earth or sea.

As will be explained in the section on Australian rainfall, these monsoonal winds from the north are the **chief rain-bringers of North and Central Australia.** That portion of Australia lying in the temperate zone (by far the most important industrially) is, however, dominated by a series of huge eddies in the atmosphere, gradually moving to the east, which are known as the **anticyclones.**

Let us consider the path of the return-trades once more, as shown in Fig. 6. There are several outstanding facts on which to base our hypotheses. At the equator the ascending air must flow poleward, as explained previously. At latitude 40° S. ('the roaring forties'), a very constant wind blows from the west and is known as the 'Brave West Wind'. Between these two belts we have a zone in which the surface air moves as a system of great whirls, while the whole moves bodily to the east. Finally, observations have shown that at considerable elevations above sea-level in New South Wales a fairly constant westerly wind is blowing which may be in a contrary direction to that experienced below. This has been shown by balloon flights, and by the records of the Mt. Kosciusko Observatory at an altitude of 7,000 feet. There would therefore seem to be some foundation for the theory that the 'Brave West Winds' are practically continuous with portions of the counter-trades.

Between latitudes 20° and 40° we may imagine, therefore, a broad belt of air at an elevation of several thousand feet always blowing from west to east. A glance at a globe or map will show that this belt lies over the most open expanse of the Earth's surface. In fact, only three obstructions occur in its path. They are the three southern projections of the land triangles discussed previously; namely, the Southern Andes, the Drakensbergen, and the Eastern Highlands of Australia.

What happens in a river, when rock-bars cross its bed? The water near the obstructions is thrown into a series of more or less permanent eddies which have a constant rotational movement together with a gradual movement down-stream. Some similar effect may occur in the westerly drift.

It is, however, more probable that variations in the **heating of the upper air** and in the resultant movements of the atmosphere cause the anticyclones (high pressure systems) and cyclones (low pressure systems).

There is no doubt that there is an almost **permanent Anticyclone** in the Indian Ocean (as in other large

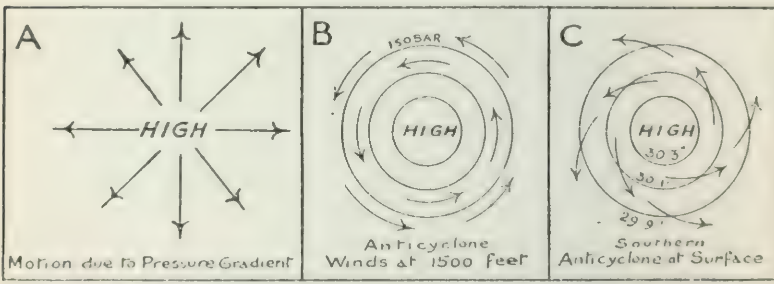

FIG. 10. The Pressure Gradient in an Anticyclone forces the air outwards radially (as in A). The Ferrel rotation effect acts in opposition, so that the winds blow parallel to the Isobars (as in B). At the surface, however, earth friction weakens the Ferrel effect, and the winds blow (as in C). N.B. The eddies are usually oval, as in Figs. 11 B and 12 A.

oceans) situated where the Antarctic current sends a body of cold water into the Tropics. These 'centres of action' are 'foci' in the high pressure belt explained previously. From this large area of High Pressure smaller Anticyclones 'bud off' as it were, presumably when the accumulation of air exceeds equilibrium. They cross over Australia from west to east about once a week, moving at about **400 miles a day.**

Each Anticyclone (or HIGH) consists of an eddy about 2,000 miles across consisting chiefly of **descending air.**

It is probably only about four miles high: for above that height the cloud movements are often unaffected by it.

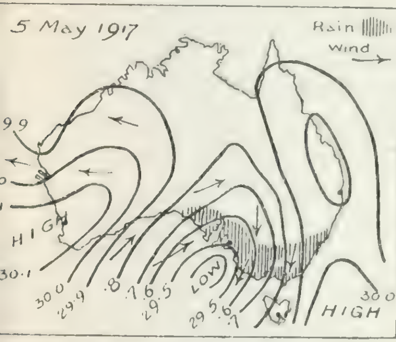

FIG. 11 A. A strong Antarctic Low between two Highs. It has moved over the Bight from the west, and is giving rain to the south-east of Australia. (Four days later shown in Fig. 11 B.)

FIG. 11 B. The High in the west in Fig. 11 A has now covered Central Australia. Its track is shown by the dated centres. In the south-east is the Low of Fig. 11 A.

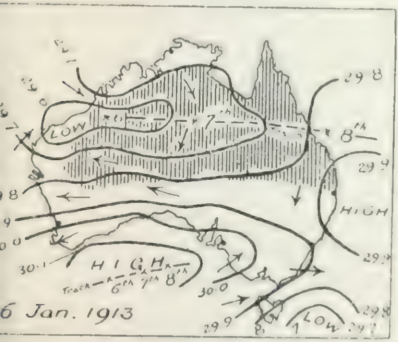

FIG. 12 A. A Tropical Low is in the north-west of Australia. Its front winds are giving heavy rains in North Australia. It is moving to the east, and its centres on the next two days are shown by the stars. In the south is an anticyclone, also moving to the east.

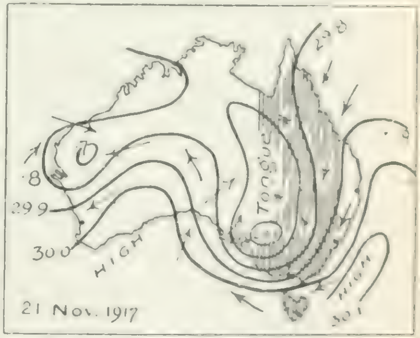

FIG. 12 B. A Tropical Tongue which has developed from a Low (like that in Fig. 12 A). It has displaced the High to the south. Flood rains in East Australia are often due to such Tongues.

Two chief factors affect the air composing it. The surface air is trying to move radially away from the centre of high pressure (along the 'pressure gradient'); and the effect of the rotation of the earth (by Ferrel's law) is to oppose this force and make the winds blow **around the centre to the left, and along the Isobars**[1] (see Fig. 10). Their motion is **counter-clockwise** in the southern hemisphere.

For reasons which depend chiefly on the friction of the earth, there is a tendency for the outward-pressure effect **at the surface** to be stronger than the rotation-effect. Here, therefore, the winds blow around the centre but tend also **to leave the centre**, as shown in Fig. 10c.

We are not here much concerned with the weather which accompanies an anticyclone. But since the air is descending it is compressed and heated. Hence it absorbs moisture (see page 46), and as a result the central region of an anticyclone is always **clear and rainless.** The winds at its front (east) are from the south, and are cool and often rain-bringers. At its rear are north winds from the interior, which are very hot in summer (see Fig. 11 B).

Alternating with the anticyclones are a set of complementary eddies called **Cyclones** (or LOWS). These occur in two belts in our region. **Tropical Lows** (Fig. 12 A) are common in summer, and often hover over our northern areas for many days before they move to the south-east. **Antarctic Lows** (Figs. 11 A and 11 B) are common in winter and move more regularly to the east along our southern coasts.

Almost all our rainfall is due to these two types of cyclones.[2] They are smaller in area and much more

[1] Isobars are lines of equal barometric pressure. The isobar of 29·9 inches usually separates Highs from Lows in Australia. The centre of a High is about 30·3 and of a Low about 29·5 inches.

[2] The word *cyclone* should not be used for local very destructive storms (tornadoes), or for the hurricanes which devastate large regions in the Tropics.

irregular than the anticyclones. They are largely regions of **ascending air**—which is chilled and deposits its moisture (see page 46). Hence they are always cloud-formers, and their isobars are usually much closer together—which implies strong winds.

The winds around an Australian cyclone blow **clockwise,** and (at the surface) spirally toward the centre. The winds at the east or front of the eddy are from the north. It is the cooling of these tropical winds that causes our chief rainfall. At the rear of a Low (or cyclone) the winds are from the south.

CHAPTER IV

THE RAINFALL OF AUSTRALIA

THERE is a loose phrase much used by rain-prophets and others to the effect that 'mountains attract the rain'. They have noted the fact that in general **mountains are wetter** than lowlands; but as the explanation is by no means obvious it will be well to explain briefly why the wetter regions of Australia are so closely correlated with the highlands of the continent. It depends essentially on a simple physical relation between water-vapour and the atmosphere.

A cubic foot of air will carry eleven grains of water-vapour so long as its temperature remains *above* 80° F. (which temperature is the dew-point for that amount of water). But as soon as the **air is chilled**—no matter by what method, whether by elevation or by transfer to cooler regions at the same level or in any other way—a proportion of this vapour will descend as mist or rain. Thus, if its temperature be reduced by twenty degrees (to 60° F.) it will lose about half its water-vapour contents ($5\frac{1}{2}$ grains) in the form of liquid water. If it be reduced to 20° F. it will lose all but one grain of water.

If a wind carrying moisture comes to a range of mountains across its path it is compelled to rise to surmount the barrier. Roughly speaking, **an ascent of 3,000 feet causes a drop of 10° F.**, whereas to attain the same degree of coolness by moving along the level toward the

Poles in the latitudes with which we are dealing it would be necessary to travel approximately 700 miles.[1]

The relation of the chief wet areas of the World to the dominant winds and highlands is clearly shown in Fig. 14; but an example of local conditions may make the relative values of these two important methods (by transfer or by elevation) of temperature-decrease somewhat clearer.

Let us imagine a sea-breeze arising near Cairns in northern Queensland. Here the Bellenden Ker Mountains reach a height of over 5,000 feet within a few miles of the sea. If the sea-breeze succeeded in crossing these mountains its temperature would decrease nearly twenty degrees, and a large proportion of its water would fall as rain. But how far would the wind need to travel south *at sea-level* to suffer a like loss of temperature? In July the isotherm of 70° F. passes through Cairns, while the 50° F. is not reached until we arrive at Cape Howe, fifteen hundred miles south!

Unfortunately Australia has **few land-masses over 3,000 feet high,** and they are practically all grouped along the eastern coast, where (see Fig. 13) the maximum rainfall occurs.[2]

An examination of Fig. 13 (in conjunction with Figs. 4 and 14) will show that three factors control the rainfall. These are **latitude,** the **trade winds,** and **topography.** The sun appears to swing north and south from latitude 23° N. to latitude 23° S. Hence the continent is affected by different rainfall controls according to his position.

When the sun is far north (in our **winter**) the Antarctic Lows move northward and affect our south coasts (see

[1] The mean annual temperature in the latitudes under consideration decreases approximately one *Fahrenheit* degree for each *geographical* degree (70 miles) traversed on the southward path.

[2] For instance in four days, January 31–February 3, 1893, over six *feet* of rain fell at Crohamhurst (45 miles north west of Brisbane).

July, Fig. 15 c). Especially favoured are the three or four regions which **project southward.** These are Swanland (or south-west of West Australia), the three peninsulas of South Australia, Southern Victoria, and Tasmania. Only the coastal fringe north of the Bight benefits.

As the **sun moves southward** (after June 21) the

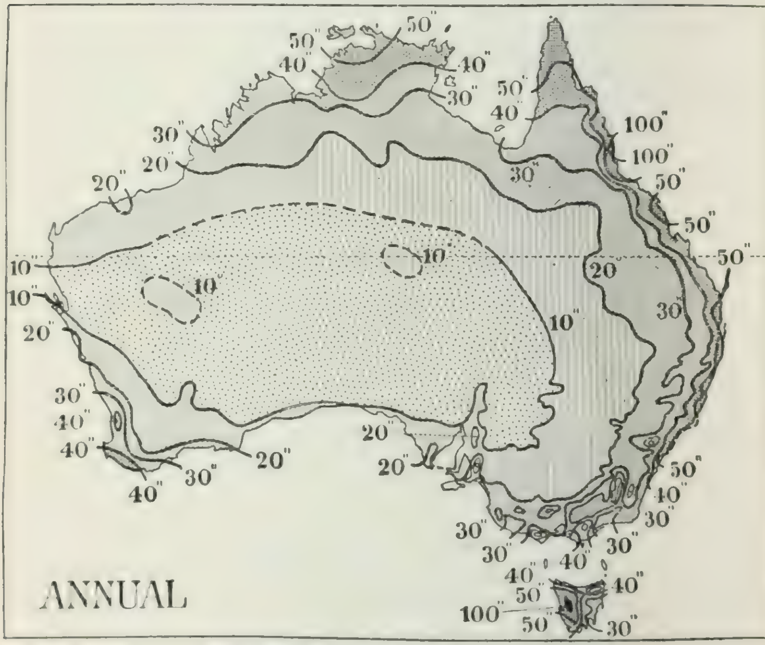

Fig. 13. Mean Annual Rainfall.

whole air circulation also swings south, until in midsummer (when the sun is vertically over our tropics) the whole northern portion of the continent is in a favourable position to receive the **monsoonal rains** (Fig. 15 c). But this effect does not reach far south.

Australia is most unfortunate in that so large a proportion (nearly 40 per cent.) of her area lies in the arid latitudes between the summer rain areas and the winter rain areas. If Australia could be moved 10 degrees (700 miles) to the southward, we should be right in the path of the Antarctic Lows; and Australia would resemble U.S.A. in her vast areas of well-watered agricultural lands.

The **arid region** between the two types of rainfall is dominated by the Trade Winds. These blow all the year round in Queensland and Central Australia, and for eight months of the year in North-West Australia. Their effect

FIG. 14. Winds and Rainfall of Globe.

is good on the east coast, and very bad in the interior and in the west. All along the east coast to the north of New South Wales the winds blow from the Pacific to the land. They are **moist onshore winds**, and give the heavy rains which rise to 165 inches a year at Harvey Creek near Cairns. As they pass inland their effect is less and less. They warm up, and so **tend to absorb moisture**, for they are gradually approaching the equator. So that when they reach Central Queensland these south-east winds are useless as rain-bringers—and they are drier and drier as we proceed to the centre and across to the west coast. Thus the arid patch of west coast near Shark's Bay is nature's compensation for the abnormally heavy rainfall on the opposite Queensland coast.

The infrequent rainstorms in the interior are due to **erratic thunderstorms** or to infrequent monsoonal tongues such as that shown in Fig. 12 B. (The effect of this lack of rain on settlement is discussed in Chapter I.)

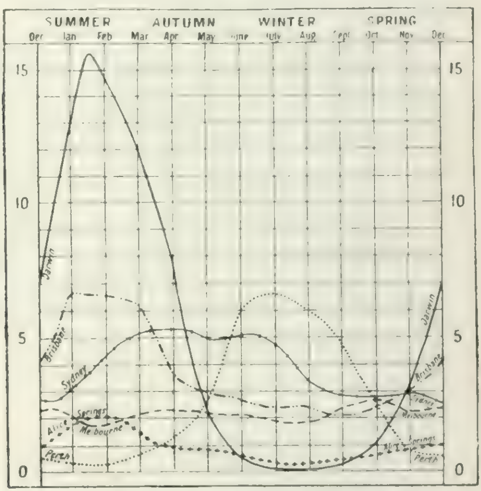

FIG. 15. Seasonal Rainfall Curves. Contrast the summer rainfall at Darwin, the winter rainfall at Perth, the autumn rainfall at Sydney, and the uniform rainfall at Melbourne. (See also Fig. 15 A.)

It has often been stated that if Australia had **high mountains in the interior** all the desert would disappear. This is not true. The MacDonnell Ranges rise to 4,800 feet and their effect is almost negligible. Moreover, in similar latitudes in South America there are mountains 20,000 feet high, and yet their flanks receive a poor 10 inches of rain in the year. Probably it would be better for Australia if the greater part of our arid interior were part of the sea. Perhaps the better rainfall in the centre in Tertiary times was due to the inland sea which extended far up the Murray basin.

Since so small a proportion of Australia (154,000 square miles, or 5 per cent.) is over 2,000 feet, the **topographic factor** does not affect large areas. But it is very important in the most closely settled regions. The **Darling Scarp**

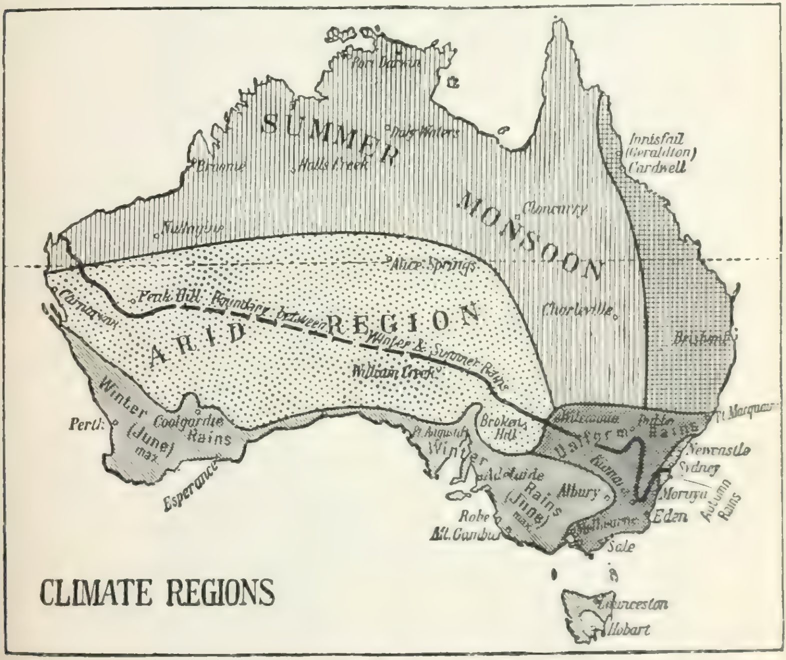

FIG. 15 A.

near Perth receives 40 inches, and is covered with magnificent Karri gums. The **Flinders Range** in South Australia causes the 10-inch isohyet to be carried nearly 200 miles north into the arid interior. The **Otway Ranges** and Strzelecki Ranges in Southern Victoria are similarly benefited. To the east of these ranges the country lies in the '**rain-shadow**' of the westerly rain-winds, and so arise the locally dry areas of Geelong and Sale. Every plateau and valley along the east coast shows the great effect of elevation upon rainfall—but this aspect is discussed in greater detail in later sections.

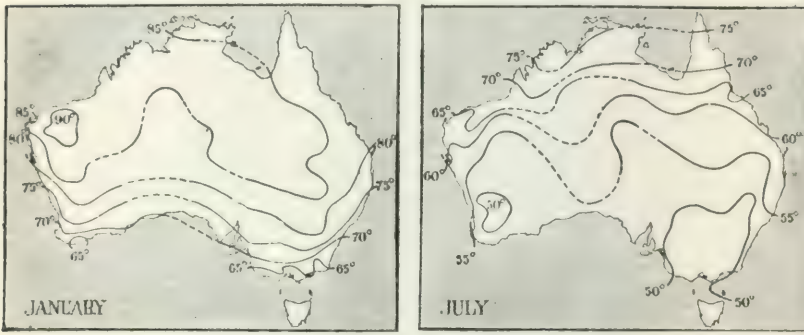

FIG. 15 B. Temperature.

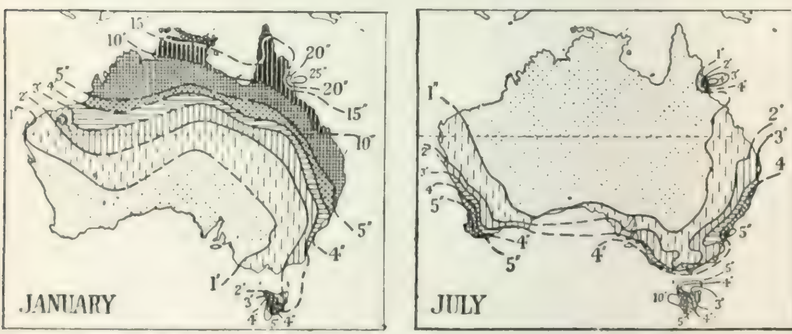

FIG. 15 C. Rain.

The rainfall in Central Australia occurs at rare and irregular intervals, generally in the warmer months, and is often associated with thunderstorms. I have started out, under apparently normal weather conditions, in the arid regions east of Lake Torrens—where not a drop of rain had fallen for nearly a year—and within half an hour I have been driven back by a tremendous rainstorm which flooded all the creeks and covered the whole district with a sheet of water. The meteorology of the desert rainfall has not been investigated, but probably here—as elsewhere—these sudden and violent rainstorms are due to unusual instability in the atmosphere. If a pronounced difference arises between the temperature of the lower *warmer* air and upper cooler air, the former tends to rise,[1] and may ascend to a point where the temperature is a good deal below the dew-point. Hence drops of rain form and these gradually coalesce. At the same time the electrical charges which always exist to some degree on their surfaces are added together, and finally become too concentrated for the reduced surface areas of the *coalesced* drops. Hence the electric discharge which usually accompanies such storms.

The causes which produce rain along the **east coast** are not quite so simple. The **anticyclones** move along tracks which usually pass over the region between Brisbane and Melbourne. In an anticyclone the frontal winds are from the south-west or south, and these are rain-bringers of some importance along the coastal fringe. But it is the Tropical and Antarctic Lows which give us nearly all our rain in the east.

In Figs. 11 and 12 are shown three very important types of cyclone (or Low). **The Tropical** (in Fig. 12 A) draws in warm moist air from the Tropical seas. On reaching the area of low pressure the air rises, is chilled, and deposits its water contents as explained previously. Next day the whole system may have moved 600 miles to the east, and the rain is gradually carried across the continent. This type of storm gives rise to much of the rain in Queensland.

[1] Russell (in his *Meteorology*, p. 125) states that this interchange of air will take place if the decrease of temperature with height is greater than 0·58 of a degree in 100 feet.

Sometimes the Low Pressure seems to grow in strength and 'pushes away' the anticyclone which usually lies to the south. A very good example of this is seen in Fig. 12 B, where the **Tropical Tongue** has reached to Victoria. An immense stream of warm moist air is carried into cooler latitudes (along the east of the tongue), and here the water is condensed, and may give rise to floods throughout East Australia.

A special class of tropical cyclones moves down the east coast, especially in autumn. They give rise to much rain, and cause the 'hump' in the Sydney graph (in Fig. 15) for March and April.

The **Antarctic cyclone** (shown in Fig. 11 A) is an important rain-bringer to the southern states. It is especially beneficial when a sort of trough extends to the Tropics, as shown by the isobars in Fig. 11 A. The Antarctics move along much more regularly than the Tropical Lows or Tongues. They are, however, rarely completely charted because their isobars are chiefly far south of Australia (see Fig. 11 B). Hence the difficulty of forecasting the Victorian rainfall.

SECTION III. THE NATURAL REGIONS OF AUSTRALIA

CHAPTER V

AUSTRALIAN VEGETATION

Before passing on to consider the separate geographical units of which Australia is composed, with their individual industries and environments, it seems advisable to make a brief survey of the most easily utilized gift of nature to man—the vegetation of the continent. The broad features are shown in Fig. 16, and are obviously almost **wholly dependent on rainfall.**

The **tropical forests** are found only where there is a fairly uniform rainfall. Hence they are confined to the eastern coast. Near Cairns is the heaviest rainfall in Australia, and here it will be found—as the writer discovered—easier to penetrate the 'scrub' on all-fours—owing to the mass of canes, lianas, and creepers—than to progress in an ordinary position. The forests consist largely of **soft-woods**—the eucalypts being comparatively rare—and an 'outlier' of somewhat similar timber, known as the 'Soft-wood Brush', occurs as far south as the north-east of New South Wales. The extent of these tropical forests is not well known, but they are somewhat irregularly distributed throughout the coastal tropical districts where the rainfall exceeds thirty inches.[1] (See page 208.)

The **thick Eucalypt Forests** occur in the well-watered coastal regions of the south-west corner and east of the

[1] Data as to the *less thickly timbered* districts in the tropics is not available. The reader (acquainted with German) is referred to Diel's work on the West Australian Flora for an interesting discussion of the flora of the continent.

continent. Although in certain regions they form dense masses of timber, as in Gippsland, yet in general they are of an open park-like character with little underwood. For this reason grass grows fairly well in these regions and they are eminently suited for pastoral purposes.

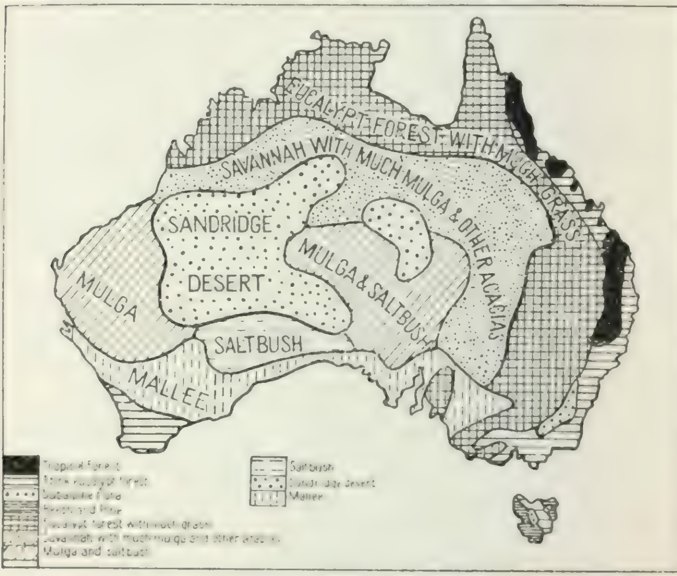

FIG. 16. Vegetation. N.B.—Mulga is an acacia, mallee is a eucalypt. The regions merge into each other.

They differ greatly from the Coniferous Forests of Europe—so thick that the sunlight does not reach the needle-covered carpet beneath—or the shady groves of oaks and beeches with their swelling masses of foliage. It is, however, incorrect to say that the eucalypts give no shade, for many have quite broad leaves. When they are young all have a comparatively close foliage, but as they grow old they usually become gaunt, sparsely-leaved giants.

This gives Australia a characteristic, and to some people a repellent, style of scenery.

Gradually, as the more arid regions of the continent are approached, the large trees become more and more isolated. **Along the watercourses** long files of gums form an advanced guard as it were—where the river has the same effect as a more copious rainfall. Thus the forests merge imperceptibly into the park-lands and these into the prairies.

The area on the map classified as forest land, as well as the outer zone of the prairie, is suited—so far as the rainfall is concerned—for **agriculture.** In fact the timber areas are superior to the prairies in most cases, and the best land has passed through the stages of 'ring-barking' and 'burning-off'—a wasteful but hitherto apparently necessary preliminary towards agriculture. Experience shows (see Figs. 41 and 41 A) that **in the south** wheat can be grown with an annual rainfall of **less than ten inches,** for here it falls just at the best season. But in the north the limit of agriculture moves much farther away from the arid centre of the continent. There is, however, no agriculture in the tropics except in a fringe along the Queensland coast.

The greater part of the savanna woods and prairie and some of the mulga scrub is suited for **pasture,** provided that sufficient grazing ground be allotted to each head of stock. In drought seasons, however, the food-supply within the ten-inch isohyet is very small and almost necessitates a transfer of all the stock to less arid regions.

The region within the ten-inch isohyet in the east has been divided into a Lower and Higher Steppe (see Fig. 28). The former comprises the Lake Eyre Basin and largely consists of '**gibber plains**' (barren stony wastes, of which Sturt's Stony Desert is an example) or less barren loamy tracts supporting some salt-bush. The Higher Steppe includes the Highlands of Central Australia, and portions of it are well grassed (see pages 122–6) and support clumps of the acacia called 'mulga'.

Between the grass-land zone and the desert[1] flourish the indigenous **salt-bush** and blue-bush.[2] These are characteristic of the country receiving about 10 inches of rainfall a year and are both low fleshy-leaved shrubs, with a characteristic grey colour, on which sheep feed eagerly. This zone gives place to the monotonous wastes dotted on the sketch-map, where the wind has swept the sand into long parallel ridges, while the only vegetation consists of thickets of **wiry 'mulga'** (a low acacia) and the prickly 'porcupine grass'.[3] Here is no possibility of permanent pastoral occupation. Indeed it is only in winter that enough water and feed exist to allow the explorer to cross (p. 120). However, a permanent **stock route** has been established between Northern Territory and Western Australia and also between Hergott (South Australia) and Queensland (see p. 157 and foot-note p. 21).

There is one small region in Australia where another factor—elevation—greatly influences the vegetation. In the Australian Alps in the south-east, the land rises above the tree-line, and here an **alpine flora** appears when the snows melt. But the sturdy 'mountain gums' rise to the 5,000-foot level, so that the alpine area is quite small and of little economic importance. It is somewhat larger in Tasmania.

[1] An American authority uses the term *desert* for regions with less than *twelve* inches of rain. While admitting that some pastoral occupation is possible in lands with less than *ten* inches, we think this term permissible for the area in Australia lying within the ten-inch isohyet.

[2] A good account of these valuable native fodder plants is given by Mr. Maiden in the *New South Wales Year Book*, 1905–6, p. 756.

[3] *Triodia irritans* or false spinifex.

CHAPTER VI

THE CORRELATION OF GEOGRAPHICAL REGIONS

SINCE the factors affecting the climates of the various regions of the World are to a certain extent symmetrical about the equator, and since it has been shown (page 38) that there is a definite arrangement to be observed in the position and shape of the great land-masses, it follows that there should be a certain similarity of climate, not only in regions along the same latitude but also in regions approximately the same distance on the other side of the equator.

The striking relation between the great deserts of the World and the trade winds has already been indicated (see Fig. 14). A similar arrangement of the wetter regions of the World is also observable. In each hemisphere we have the region of westerly winds; blowing constantly in latitude 40° S. and not so regularly in latitude 45° N. Arising from this air-current we have **three well-defined wet regions in the southern hemisphere,** namely Southern Chile, Tasmania, and New Zealand (South Island). In the northern hemisphere similar conditions obtain in British Columbia and Ireland. On the **eastern shores** of the great continents we have much **drier regions** with a fair rainfall having great similarity in climate. Such are Uruguay, Natal, New South Wales; and in the northern hemisphere the eastern states of U.S.A. and China.

Such similarity in climate and position must react on the life and industries of the inhabitants, and a study of this question may well form the basis of a general scheme of geographical regions which should be very helpful in connexion with that branch of economics dealing with supply and demand. For it will be seen that the products of any one of these analogous regions are those of the others, or if not already there will probably thrive if introduced. For instance, China grows *silk* and *tea*, U.S.A. grows *cotton*, New South Wales at present has not passed the experimental stage in any of these crops but (apart from labour conditions) there is no geographical reason

FIG. 17. Correlation with Australian Climates based on A. J. Herbertson's Regions. Regions allied to Australia are tinted.

why they should not do well in certain portions of the mother state of Australia.

This line of research has been ably developed by Dr. Herbertson,[1] and Fig. 17 is based on his map, being altered, however, to suit Australian conditions. On this plan Australia may be divided into **six climatological regions.**

1. Savanna.	4. Riverina.
2. Desert.	5. Victorian.
3. Eastralian.	6. Tasmanian.

1. **Savanna.** These regions consist of moderately ele-

[1] 'Major Natural Regions', *Geog. Journal*, vol. xxv, p. 300, 1905.

vated and **sparsely timbered** country situated between the tropics and the equator; they have a hot climate **with summer rains,** and are not well situated for white farming. In the Australian province cattle and sugar are the only large industries (excluding mining). Allied provinces are Sudan and Southern Brazil. In these countries large crops of rice, sugar, tobacco, rubber, and cotton, together with less important products, are grown, and would probably flourish equally well in the Australian province.

2. **Desert or Arid.** In the Australian province with a rainfall less than 10 inches a year, the margin is used as pastoral land, and what may be termed 'oases' occur, especially near the MacDonnell Ranges. As in the other regions, Sahara, Kalahari, Atacama, Arabia, Arizona, it is only sparsely inhabited, civilization concerning itself with the preservation of travelling routes by means of artificial water-supply. However, where rich mineral deposits occur, as at Coolgardie, Atacama, &c., large settlements may flourish.

3. **Eastralian.** This comprises in Australia the Eastern and Central Divisions of New South Wales and Southern Queensland. It is characterized by a **warm, temperate** climate (45°–70°) having a **moderate rainfall,** mostly falling in summer, varying from 20″ to 70″ according to the distance from the coast. It is pre-eminently a farming country, being devoted largely to dairying and small crops generally. Cattle pay well in the more elevated regions. Allied regions are China and Eastern U.S.A., where, however, the winters are much colder. Hence, in addition to the above items, silk, cotton, and tea may be cited as possible products of agriculture.

4. **Riverina.**[1] This name is given to the western

[1] Here the name Riverina is used as a *type* region and is extended to include the 'Western Plains' of N. S. Wales and of S. W. Queensland. See Fig. 24.

region of New South Wales watered by the lower portions of the great tributaries of the Murray River, i. e. Lachlan, Murrumbidgee, and Murray itself. It is thus a region of interior lowlands with a **warm, dry climate,** excelling in the production of wool and wheat. Allied regions are found in the prairies of N. America, the pampas of S. America, and the plains of Southern Siberia. These are also great wheat-growing regions, and are ahead of Australia in that respect, but as a wool-raiser the Riverina country is perhaps the best in the world.

5. **Victorian.** These regions have a **warm, temperate** climate, somewhat colder, however, than the preceding. The greatest **rainfall is in the winter.** At this period the Sun moves north and is followed by the general wind system. Hence Southern Australia is brought more under the influence of the moisture-laden westerlies, whose track is *south* of the continent in summer. Analogous regions are the Mediterranean countries, Cape Town, &c. As in Australia, these provinces excel in the growth of vines, olives, cattle, wheat. It will be noted that though the products are the same in both northern and southern regions, yet the **times of harvests differ** very considerably in the two cases, a fact of increasing importance in connexion with the supply to the great northern populations.

6. **Tasmanian. Cool, temperate climate,** considerable rainfall, and snow by no means rare. Chief products are fruit, sheep, and timber. Similar conditions resulting in similar products occur in New Zealand, Western Europe, British Columbia, and South Chile. It is noteworthy that their waters are usually good fishing-grounds, while the climate is one of the most pleasant in the world.

CHAPTER VII

THE CLIMATIC CONTROL OF SETTLEMENT

THERE can be little doubt that climate is the major factor in determining the permanent settlement of the various regions of the earth. It controls agriculture and grazing, which in their turn largely determine manufacturing industries. It controls comfort and health—very potent factors in the spread of white civilizations. In fact were it not for certain valuable mineral deposits, one would find that practically all the main centres of white settlement could be defined in terms of temperature humidity and rainfall.

Similar controls no doubt operate in connexion with other races. Probably the black race flourishes within narrower limits and the yellow race within wider limits than the white race—but a very short survey will show that the Australian Commonwealth contains regions akin to those inhabited by types of each of the great races of mankind.

Thus, in regions akin to Tasmania are the tall fair-haired Nordic races. In those Mediterranean lands like our south coasts are 'Alpine roundheads' and short, dark Iberians as in Spain. In Egypt and near by are Semitic peoples, Copts and Syrians, who dwell in regions like our Riverina. In the true desert are the Tuaregs of mixed origin.

The yellow Kirghiz of the Caspian steppes live in regions akin to our Artesian Basin; the Chinese inhabit lands of the same climate as New South Wales.

The savannas of the Sudan are like those of northern

Australia, but are peopled by pure **negroes.** The south of India closely resembles our north-west coasts, and is inhabited by **dark Dravidians** of doubtful ancestry.

Here, indeed, is a diversity of creatures, whose whole scheme of life is largely determined by their environment. In Australia the environment is as diverse, and it is logical to assume that it will exert a potent, if slow and hidden, influence on Australians.

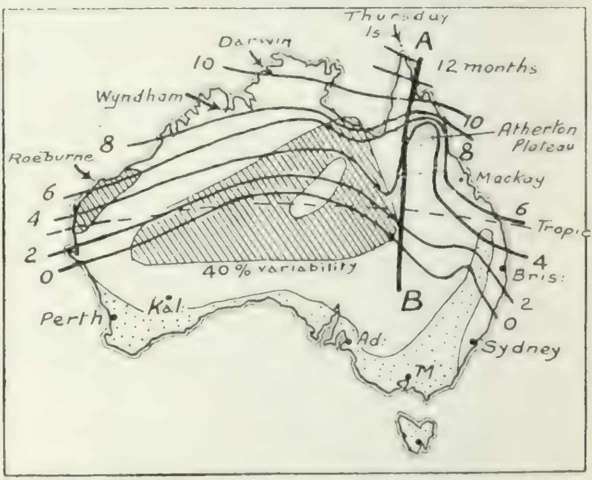

FIG. 17 A. Climatic Control of Settlement. The line *AB* separates the eastern fairly uniform rain region from the western winter-drought region. Shaded areas have very erratic rains (over 40 per cent. variability). The curved lines connect points having the same number of months with an average wet-bulb temperature of 70° F. Thus Thursday Island has twelve months and Brisbane two months of that condition. The dotted area has reliable rains with less than 20 per cent. variability.

Since the southern and south-east portions of Australia are blessed with a climate admirably suited to our race, only the northern areas will be discussed.

Temperature. While in general the southern hemisphere is cooler than the northern—owing to the great extent of ocean—yet the large southern land-masses are not much benefited. Thus tropical Australia is much hotter than any region to the north of it, and hence the '**heat equator**' must be drawn through Wyndham (W.A.) and Darwin.

Indeed North-West Australia is one of the four hottest regions on the earth, and **Wyndham** has an unenviable position as the hottest *moist* locality where meteorological records have been taken.

Elevation. Large portions of British tropical areas are luckily situated at high altitudes. Thus in Rhodesia 90 per cent. of the area is over 2,000 feet. This **lowers the temperature** some 7° F., and is a vital factor in regard to settlement.

In Australia only **4 per cent.** of tropical Australia is high enough to benefit in this respect. In fact the **Atherton Plateau** in North-East Queensland is the only important tropical plateau. It is about 12,000 square miles, and two similar areas on the Tropic (in the centre and west of the continent) exhaust the list.

Range of Temperature. In cooler regions a moderate range of temperature is desirable, in hot regions the **greater the range the better.** It is only in the north of Australia that this factor is of importance. Unluckily, on the coast the proximity to a warm ocean (whose annual range is only a few degrees each side of 80° F.) keeps the land temperatures constant. Thus Darwin has an average of 84° F. in July and of 77° F. in January; while Thursday Island has a range of only 5·5° F.

Rainfall. We have discussed earlier the average rainfall and the season of the rain. In the south conditions are favourable for crops—for the rain falls **chiefly in winter** just when our main crop (wheat) benefits from the fall. A dry summer is advantageous, for it ripens the grain well. On the north coast nature is not so kindly.

Here the rainfall occurs **wholly in summer**, and for the six months of winter not a drop falls. This has a great bearing on the vegetation. No tropical shrubs, lianas, ferns, &c., can survive the winter drought, and consequently there is an almost total **absence of true tropical forest** in the north. Hence we realize that the 62 inches which fall at Darwin are much less useful than the 40 inches which fall in Southern Victoria.

A factor of even greater importance is the **reliability** of the rain. Northam (near Perth) has 15 inches of rain. It falls regularly, just when it will benefit the wheat crop. Roeburne on the north-west coast also has an average of 15 inches a year. But in 1900 there fell 42 inches; and in 1891 there fell less than one inch! Proceeding along these lines we can determine where the rainfall is reliable and where it is not, and as a result we get the two areas shown in Fig. 17A, in each of which a variation from the normal of 40 per cent. is to be expected.

Fig. 17A shows us that the northern half of the arid region (see Fig. 13) is much less reliable than the southern half. Hence pastoral occupation will be safer along the new Transcontinental Railway than it will in regions with similar low rainfall in the Territory. It shows us that the Barkly Tableland (south of the Gulf of Carpentaria) is a very unpromising field for agriculture—though wheat-growing has been seriously suggested.

Wet Bulb and Comfort. The best test of a tropical region as to its habitability is probably by the **wet-bulb thermometer.** Regions with a hot *moist* (muggy) climate show high wet-bulb readings. Regions with hot dry temperatures show very much lower wet-bulb readings.

The average monthly temperature of **70° F. (wet-bulb)** has been adopted by some writers as the limit of comfort for our race. This means that when the average wet bulb remains above 70° F. day after day for months at a time, conditions are not favourable for close white settlement.

There are usually many unpleasant muggy days in **Sydney in February,** and a few occur in Melbourne. Yet Sydney has no month approaching an average of 70° wet bulb. Brisbane has two such disagreeable months, and conditions become continuously less attractive as we travel up the coast. At Mackay there are six such uncomfortable months, and at Thursday Island there are twelve. Lines are drawn on the map in Fig. 17A to show the number of months of this nature.

It is possible that the **steady winds** of the Tropics do something to counteract these high wet-bulb readings. But these climatic conditions obviously make it very difficult to establish agricultural settlements along our northern coasts. There are, indeed, only ten farmers in the Territory.

One great asset these coasts possess—their remarkable freedom from such **tropical diseases** as yellow fever. Even malaria is rapidly diminishing in importance.

Speaking generally, therefore, the region west of the line *A B* (in Fig. 17A) is a **pastoral area,** and as such it must be developed. We need more wells, tanks, and artesian bores to tide them through the long winter-drought. We need **more railways** to open up the country; and to ensure the safety of the flocks in the long droughts which will continue—at frequent intervals—to curse the inland regions of the Commonwealth.

CHAPTER VIII

THE EASTERN HIGHLANDS OR CORDILLERA AREA

Introduction

ALTHOUGH the climatological regions of Chapter VI are of the utmost value for comparison with similar regions

FIG. 18. Topographical Regions of Australia.

A. Eastern Highland or Cordillera Region: I, Queensland Highlands; II, South-east Littoral; III, South-east Highlands; IV, Tasmania.

B. Murray-Darling Basin: I, Gold-copper Slope; II, Western Plains; III, Tertiary Sea.

C. South Australian Highlands and Rifts: I, South Australian or Cambrian Highlands; II, Torrens Rift.

D. Artesian Basin: I, Eastern Division; II, Lake Eyre Basin.

E. Great Plateau Region: I, Tropical Division; II, Temperate Division: III, Desert Region.

in other continents, yet as regards its internal physiography Australia can be more satisfactorily divided into five topographical regions. Of these three (A, D, E) are well defined, and two (B, C) are somewhat arbitrary.

(A) **The Eastern Highlands.**

(B) **Murray-Darling Lowlands.**

(C) **South Australian Highlands and Rifts.**

(D) **The Great Artesian Basin.**

(E) **The Great Tableland or Plateau Region.**

The dominating feature in the continent is the huge mass of very ancient schists, granites, and palaeozoic sediments which form region E, and constitute the greater portion of the states of West and South Australia. In fact they build up one of the oldest land masses on the globe. During later periods the Eastern Cordillera Region (A) was elevated above sea-level, not all at once, but probably at the close of the palaeozoic age most of it was dry land. The sediments deposited between these two land areas have been raised above sea-level in still later geological times, and constitute the Artesian and Murray-Darling Regions (D and B). The geological history of these regions is discussed more fully later.

Eastern Highlands. This is a belt of country which runs parallel to the eastern coast from Cape York round to the mouth of the Murray. It has an average width of 150 miles and contains the chief mountains in the continent. The **seaward slope is in general steeper** than that on the west, and the Blue Mountain Scarp (N.S.W.), the bold front of which opposed the western march of settlement, is directly due to a great fold which occurred in late Tertiary times and which has definitely altered the direction of several of the rivers (i. e. Nepean and Shoalhaven). Professor Gregory has pointed out the **lack of uniformity** in the structure of this Cordillera. Granite masses buttressing blocks of carboniferous sediments build the divide near the Grampians in the south-west, slate and granite form the dome of Kosciusko (7,320 ft.). Granite again appears in the New England Highlands. The sedimentary formations from the lower silurian to the trias, with varied axes of uplift, have a part in the structure of the Highlands, so that it is not a uniform mountain range like the tertiary mountain chains such as the Andes.

There are four natural divisions.

In the north are the Queensland Highlands.

In the south-east the Cordillera is set somewhat farther back from the coast than in Queensland, and it is convenient to divide the region into two parts: the **South-East Coastal region** (A II) between the eastern edge of the elevated area and the ocean, and the **South-East Highland** (A III), which may be conveniently assumed to be bounded by the 2,000 foot contour line (see Figs. 20 and 21).

The fourth region is Tasmania.

The Queensland Highlands.

The first natural division consists of the Queensland Highlands, culminating in the **Bellenden Ker** Mountains (5,440 ft.). This region broadens towards the south, where it has a width of about 300 miles. For some 1,200 miles it is flanked by the **reefs of the Great Barrier,** whose steep outer margin is some 30 to 75 miles from the coast line. Within this wall, where each small reef represents a battlement, is an inland sea averaging some 20 fathoms deep, along which sail the steamers trading to and from China, India, and Japan. The trade in pearl-shell, tortoise-shell, and bêche-de-mer is described in another section (Chapter XXII).

FIG. 19. The Queensland Highlands (A 1) and the Artesian Basin (D).

The coast is in the main rocky, and is fringed with islands which are relics of the subsidence of coastal ranges. Hence there are many good harbours, though level agricultural land is correspondingly rare. The river bottoms are devoted to **sugar-cane** (see pp. 211-14), and in the north, where a heavy rainfall obtains (Geraldton, between Cairns and Townsville, has 145 inches per year), all tropical productions are grown. The chief towns are situated where the rivers enter the sea or at the numerous **gold-fields** in the Cordillera. Cooktown supplies the Laura Goldfield, and incidentally New Guinea. Cairns is the port for the Chillagoe tin and copper fields. Sheep and cattle from northern Queensland and gold from Charters Towers are brought by rail to Townsville. The **Burdekin** River enters the sea between Bowen and Townsville but is of much less importance than the other large river draining the Queensland Cordillera, **the Fitzroy**, which debouches into Keppel Bay 35 miles below Rockhampton. Here a railway stretches some 400 miles inland and its course almost coincides with the tropic of Capricorn.

The valley of the Fitzroy will become one of the most populous parts of Australia, for sheep and cattle are numerous and supply the large meat works near the coast. **Mt. Morgan**, until lately one of the richest gold mines in the world, is 26 miles south of Rockhampton. The Dawson and Clermont **coalfields**, however, are probably the chief assets in this portion of the Queensland Highlands, though as yet they are an almost untouched source of wealth. South of Rockhampton the Highlands increase gradually in height and culminate in the New England 'massif', or block of elevated land, in New South Wales.

The same general features as those described for the northern part of Queensland characterize its southern portion. **Sugar ports**, such as Bundaberg and Maryborough, also serve as outlets to mining districts such as Gympie and Kilkivan. A very flourishing area of basalt country known as the **Darling Downs** is chiefly devoted to agriculture. The railway to Brisbane from its chief town, Toowoomba, also taps the **Ipswich coalfields**—the chief coal area in Queensland. The south-east coast of Queensland is free from coral reefs, but there are large sandy islands which somewhat impede navigation, such as Great Sandy, Moreton, and Stradbroke Islands. The capital, **Brisbane,** is situated in the south-east corner of the State, and is partly for this reason much less a State metropolis than are the central cities of Sydney and Melbourne. With a population of only half a million, Queensland has as many second-class towns with over 10,000 inhabitants as has New South Wales, and more than Victoria, though the latter States have one and a half million inhabitants each. Indeed, the whole population of Queensland would barely replace numerically that of either Sydney or Melbourne.

The South-East Coastal Region.

The South-East Coastal Region may be said to extend from the Macpherson Range on the Queensland border to the Mount Gambier district in the south-east corner of South Australia. It is a strip of land which varies in width as the lower river valleys are wider or more circumscribed. Thus, in New South Wales the Richmond and Clarence drain a tract of country 50 miles wide after they leave the highlands. Spurs from the New England Range isolate the smaller valleys of the Macleay and Manning, and then the coastal region spreads out again into the broader valley of the Hunter River. The Tweed, Richmond, Clarence, Macleay, and Manning are grouped together as the **North Coast Rivers.** The rain

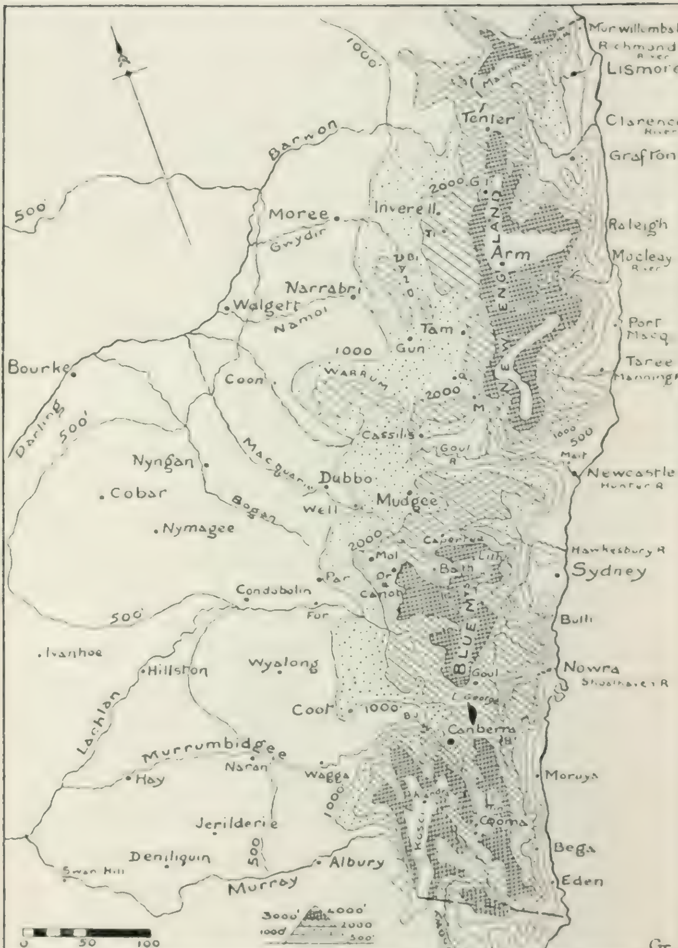

FIG. 20. Chief Contours of New South Wales. 500, 1000, 2000, 3000, and 4000 are shown.

fall is abundant and the vegetation is therefore, in general, very luxuriant. The first settlers were attracted by the valuable **cedar,** but **sugar-cane** and **dairying** have since become of much more importance. Murwillumbah on the Tweed, Lismore on the Richmond, and Grafton on the Clarence are the main centres of population. Navigation is impeded by bars in most of the rivers, but ocean-going steamers drawing 11 feet of water can reach Grafton, which is 45 miles from the ocean. The **Hunter River flats** around Maitland are renowned for their fertility, but are liable to disastrous floods, though the upper valley of the Goulburn—the chief tributary—is the driest portion of the littoral (see page 129).

Two fine harbours, Broken Bay and Port Jackson—both drowned river valleys invaded by the sea—lead into the coastal belt in the section farther south. Broken Bay receives the **Hawkesbury River,** 330 miles long, one of whose tributaries, Cataract River, rises only 2 miles from the coast (near Bulli 40 miles *south* of Sydney), and flows west (Cataract River), north-west (Nepean River), north, north-east (Hawkesbury River) and south-east, thus forming a semicircle round Sydney. Port Jackson receives no river, the so-called Parramatta River being only an arm of the sea some 10 miles long. The pre-eminence of the **harbour at Sydney** is no doubt largely due to this fact, no dredging being necessary to keep open the deep water frontages.

The trias sandstones of the county of Cumberland are poor in plant foods (see p. 18), but an upper layer of clay-shales around Parramatta supports many orchards. The Hawkesbury River flats near Windsor and Penrith below the Blue Mountain Scarp are the chief agricultural areas. The **coal-mining** and dairying industries are discussed in separate sections.

South of Sydney the littoral belt is much narrower for some distance. The first well-marked district is the important **Illawarra** dairy country which surrounds the lagoon 'Lake' Illawarra and the mouth of the Shoalhaven River. In the ranges behind the dairy farms **excellent coal** crops out. As the rainfall is good this is one of the most flourishing districts in Australia. Bulli and Mount Kembla are the chief coal centres; while Nowra, near the mouth of the Shoalhaven, is the railway terminus and a collecting-ground for agricultural and pastoral products.

The **South Coast region** is confined to the river mouths. The mountain spurs reach the coast and contain many small **mining fields** (e. g. Moruya and Pambula) chiefly of gold and copper. Moruya (150 miles south of Sydney), on the river of the same name, and Bega (200 miles south of Sydney) are the chief towns, and, in common with the whole district, are devoted to dairy farming.

When Cape Howe is passed there is a somewhat different distribution of mountain and plain. The littoral region becomes much wider than in the south of New South Wales and merges gradually into the region called by Professor Gregory the **Great Valley of Victoria.** The latter is separated from the sea by the low Otway Ranges and the Gippsland Hills to the west and east of Port Phillip respectively. The low coast lands continue west across the mouth of the Murray to the Mount Lofty Ranges which constitute their western boundary (see (page 104).

If now we examine the Victorian portion in some detail, we see that **Gippsland** extends roughly from the Snowy River to Mount Dandenong, near Melbourne. It is one of the most prosperous portions of Australia, and one of the most interesting and beautiful. The greater width of the littoral belt here is probably due to an uplift of the coast, which has added a wide stretch of level country to Victoria, and led to the formation of the **Gippsland Lakes.**

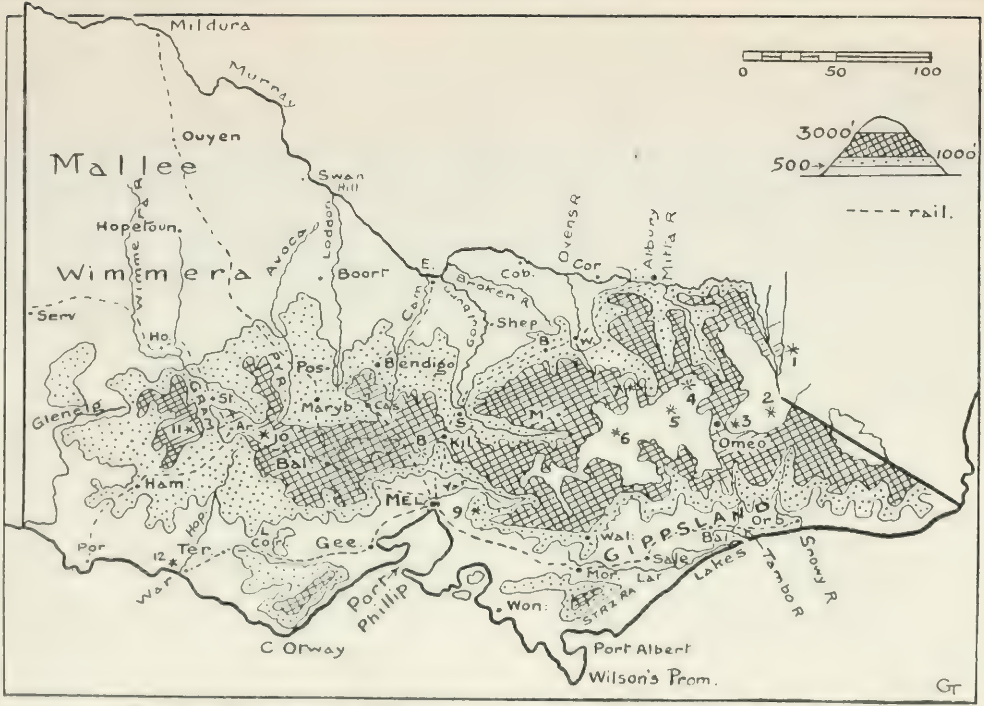

FIG. 21. Topography of Victoria, showing 500, 1000, and 3000 contours.
Notable peaks are: 1. Kosciusko (in N.S.W.); 2. Cobboras; 3. Tambo; 4. Bogong; 5. Hotham; 6. Howitt; 7. Buffalo; 8. Macedon; 9. Dandenong; 10. Buangor; 11. William; 12. Tower Hill.

There is little doubt—as Professor Gregory points out—that the Rivers Tambo, Mitchell, Thompson, and Latrobe had independent entrances to the sea when the rocks which now form the coastal plain were laid down, 'but now they have all been grafted on to one another till they form one system. The Gippsland lakes occupy the depressions along the courses of the members of this engrafted system.'[1] Sandbanks piled up by the ocean currents have largely formed the seaward margin of many of the lakes.

In the older rocks enclosing this coastal plain are **gold-mining fields**, of which Walhalla is the most noteworthy. Sale is the capital of Gippsland and is the centre of a large dairying and pastoral district. Somewhat nearer Melbourne is Morwell, where **coal** of a somewhat inferior quality is abundant. In the county of Buln-Buln, enclosed between the two railways joining Melbourne to Sale and Port Albert respectively, is a richly timbered country where the largest **hardwood trees** (*Eucalyptus regnans*) in the world flourish.[2] Maiden describes these as follows: 'The official size of the tallest Gippsland tree is given as—height 326 feet; girth 25 feet 7 in. measured 6 feet from ground; locality Mt. Baw Baw, 91 miles from Melbourne.' The Gippsland lakes (Wellington, Victoria, and King) are favourite summer resorts and furnish large supplies of fish to the Melbourne market.

Port Phillip is probably part of the Great Victorian Valley which has been drowned by the sea. It is about 40 miles wide and the same distance from the entrance to the head at **Melbourne**. The latter city is admirably situated to collect the produce of Victoria, for it is more central than any other Australian capital and, owing to the less rugged nature of the highlands behind, the inland

[1] Gregory, *Geography of Victoria*, 1903.

[2] Hutchins quotes 434 feet as the height of a Karri gum from West Australia. He measured one of 284 feet.

areas of Victoria were connected by rail to the capital much sooner than in New South Wales. Port Phillip Bay extends over 800 square miles and forms a good outer harbour for Melbourne. Lying within it, Hobson's Bay is protected on the south-west by the point on which **Williamstown** has grown up, and though most large vessels berth here (adjacent to Port Melbourne), yet steamers drawing 22 feet can enter Melbourne up the Yarra. Geelong with several woollen mills lies at the head of Corio Bay.

To the west of Port Phillip the valley extends to the South Australian border; the western district including Port Phillip was christened **Australia Felix** by its discoverer. The nearer portion of the south-west plain of Victoria owes its great fertility to the **immense areas of basalt,** which flowed from many extinct volcanic cones such as those around the salt lakes of Corangamite. The country here is chiefly pastoral, though farther west agriculture is all-important. At Warrnambool and Belfast is a population largely of Irish descent, and here pigs and potatoes are important assets in the district's wealth. Tower Hill, a well-known volcanic cone in the vicinity, was possibly the **last active volcano** in Australia. Portland was founded by some whalers from Tasmania—the first settlers in Victoria. They soon, however, turned their attention to **sheep** and at a later period bred the finest sheep in Victoria near the neighbouring town of Hamilton.

The western end of the South-East Littoral lies in South Australia. Around the **crater lakes of Mount Gambier** are large areas devoted to the growth of English fruits, potatoes, grain, and grasses, while many sheep are reared. But beyond this lies the **raised sea-floor** of the large tertiary gulf into which the Darling, Murrumbidgee, and Murray originally entered by separate mouths. The littoral portion of this old sea-floor is best considered with the Murray-Darling region (p. 101), for it can hardly be considered a portion of the Eastern Highland region whose last important heights are the Victorian Grampians.

Summarizing the districts of the South-East Coastal region, they comprise in New South Wales (1) The North Coast, (2) the Hunter Valley, (3) the Sydney District, (4) the Illawarra District, (5) the South Coast District; and in Victoria (6) the Gippsland District, (7) Port Phillip, (8) the South-Western Plain of Victoria.

The South-East Highlands.

The Highlands forming the hinterland of the South-East Coastal Region can be divided into several well-marked elements. In New South Wales there are (1) The New England Massif, (2) the Blue Mountain Massif, and (3) the Kosciusko Massif, separated by cols which are used for routes to the interior, and (4) the Victorian Highlands. (See Figs. 20, 21.)

The New England Massif.

This is composed chiefly of sediments of carboniferous age into which large masses of granite have been intruded. It extends from the Queensland border some 250 miles to the south (see Fig. 20) and is approximately 100 miles wide, with a broad off-shoot—the ancient volcanic bosses of the Nandewars—extending towards the west. It is thus the most considerable mass in the Eastern Highlands, a large proportion being over 3,000 feet (Ben Lomond, 5,000).

It forms the divide between the Macintyre, Gwydir, and Namoi rivers on the west and the Clarence, Macleay, and Manning on the east. The head-waters of the coast rivers arise in the **most rugged country** in the State, where the timbers differ considerably from those in other parts, consisting chiefly of soft woods. (See the section on timber.) Apart from small mining towns such as Drake and Hillgrove, there is little settlement; though the numerous **waterfalls**—such as Apsley Falls on a tributary of the Macleay—point to a development of water power in the future (see Fig. 20).

On the western slopes of the New England Massif the country is much less rugged and the mining industry is accompanied by agriculture and **sheep rearing.** The main northern railway follows the centre of the tableland where **Armidale** is a centre of the squatting industry. Inverell and Tingha, to the north-west of Armidale, are in the chief **tin-field** in New South Wales, while Bingara has produced many diamonds. **Wheat** is largely grown on the western slopes, as at Tamworth and Quirindi, which are on the borders of the Liverpool Plains.

For about 100 miles south of the New England Massif the Highland is much less elevated and at three points is little above 2,000 feet. At Murrurundi—the northernmost of these gaps—the railway crosses from the Hunter valley to the Liverpool Plains. The central gap, the **Cassilis Col or gap,** is largely due to the erosive action of the Goulburn River on the relatively soft coal measures constituting its bed. It forms a natural route from the Hunter valley to the gold-fields of Mudgee and Wellington. The southern gap is cut in hard triassic sandstones by the Capertee River, which has exposed rich seams of **kerosene shale** in the cliffs, but these cliffs here offer as great difficulties to travel as elsewhere in the Blue Mountains, and the route will probably never be of much use.

The Blue Mountain Massif.

The central massif culminates in the Blue Mountains (Fig. 20), which long resisted all efforts of the settlers to open a route to the west. This is due to their peculiar structure, which has given rise to the valleys (e.g. Capertee valley in Fig. 20) which astonished Darwin.

He writes, 'Great arm-like bays, expanding at their upper ends, often branch from the main valleys and penetrate the sandstone platform. . . . To descend into some of these valleys it is necessary to go round 20 miles. But the most remarkable feature in their structure is that although several miles wide at their heads they generally **contract towards their mouths** to such a degree as to become

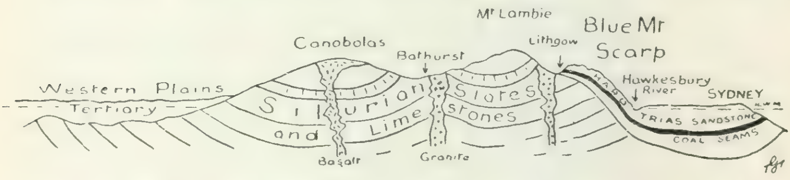

FIG. 22. Section across the Blue Mountain Massif, showing the Structure of the Scarp on the East.

impassable.' Professor David and others have proved that this 3,500 foot barrier—which rises 1,200 feet in the first 4 miles—is due to a single grand fold in the triassic strata (see Fig. 22). It will be understood that when the hard surface layer of this 'giant step' has been cut through by a river (e.g. the Capertee), it is working in softer shales everywhere except where it actually cuts through the sloping scarp; and so it eats away the sides of the upper portion of the valley more rapidly and removes the débris through the narrow opening which is all it has been able to erode in the hard stratum covering the scarp.

The sandstone platform of which Darwin speaks is—except along the railway—almost as **barren and desolate** as when he saw it about 1835. This is due to the lack of plant food in the trias sandstone, which builds excellent houses but supports a somewhat stunted and worthless vegetation. In the tract of country from Broken Bay to the head of the Goulburn—some 150 miles long and 30 broad—there is scarcely a settlement, and a similar area along the Wollondilly is equally rugged and unprofitable. At the western edge of this barren sandstone the underlying coal measures are exposed; and at **Lithgow**, where one of the few **manufacturing centres** of Australia is situated, the blast furnace for iron, the copper refining plant, and the potteries are among the largest in Australia.

The 2,000 foot contour line in this latitude encloses a compact, circular plateau about 80 miles in diameter (see Fig. 20). It is bounded on the east by the Blue Mountain Scarp (above which are the **tourist resorts** of Mount Victoria and Katoomba), on the south by the Goulburn gap; on the west its limits are less well defined, while on the north it is joined by a narrow neck near Capertee to the desolate trias plateau mentioned previously. This area is shown in section in Fig. 22.

The greater part is drained by the Macquarie and its tributaries. This river rises near the **Jenolan caves**—one of the grandest examples of limestone erosion in the world—which are visited by thousands of tourists every year. It flows through the Bathurst Plains, to which the early settlers drove their flocks when the coastal belt became too small for them. It drains the **earliest gold-field** of Australia, Lewis Ponds being the scene of Hargreaves' discovery of payable gold in 1851, while Hill End and Sofala possess quartz reefs rich in the same precious metal. On the western edge of this area arise the **old volcanic masses** of the Canobolas, and around them are the towns of Molong, Orange, and Blayney, which are all wheat-growing, mining, and pastoral townships.

On the western slopes of the Cordillera lies the great **wheat belt**, and gradually, as the base of the Highlands is buried in the alluvium of the Great Western Plains, the agricultural conditions become less favourable and wheat is wholly replaced by **sheep**. South of the Blue Mountains the elevated region of New South Wales narrows greatly until near Goulburn the 2,000 foot contour is only 20 miles wide. At the **Lake George Gate** the southern railway crosses towards Albury and Melbourne, while (as in the northern col at Murrurundi) a second railway ascends the Highlands and, proceeding south, reaches Cooma some 50 miles from Mount Kosciusko. This southern col is geographically very interesting. It is partly due to extensive faults and folds, probably allied to the Blue Mountain monocline fold behind Sydney. **Lake George**—the largest lake in New South Wales—which in 1880 was 17 miles long and nearly 30 feet deep, though in 1907 practically dry—occupies a fault valley[1] on this col (see Fig. 20).

A long ridge divides the **Shoalhaven River** from the upper waters (Wollondilly) of the Hawkesbury. It has been shown that the upper Shoalhaven ran into the upper Hawkesbury at an earlier stage in its history, though now it turns abruptly to the east and flows through deep gorges directly to the sea. The upper Shoalhaven, draining limestones and slates of older palaeozoic age, is noted for its alluvial and **reef gold**, Braidwood (Br.) and Araluen being the chief mining centres. It is interesting that the bed of the ancient junction of the Wollondilly and Shoalhaven—now 1,500 feet above the Shoalhaven—has also been profitably worked as the alluvial diggings of Barber's Creek.[2]

[1] See the *Proceedings of the Linnean Society of New South Wales*, 1906 and 1907, for three papers (by Taylor, Woolnough and Taylor, and Taylor) dealing with the geography of this district.

[2] *Proc. Linnean Soc. N.S.W.*, 1906, p. 548.

The basalt cappings on this watershed near Moss Vale have formed a rich soil which supports a large farming population amid the somewhat barren areas of trias sandstone.

The Kosciusko Massif.

The Kosciusko Massif (see Fig. 20) extends south from the Goulburn gap to beyond the Victorian border. It almost reaches the coast and is about 100 miles wide. It is drained on the north by the Murrumbidgee and on the south by the Snowy River. **Cooma,** on the divide between these river-basins, is the chief town and is the railway terminus for tourists to the chief alpine district of Australia (around Kosciusko.) At Kiandra are large alluvial diggings, and its great elevation (4,640 feet) leads to a heavy snowfall, so that 'for many months of the year the people, young and old alike, go about on snow shoes' (J. M. Taylor).

The massif terminates in the granite boss of **Mount Kosciusko** (7,350 feet), the highest mountain in Australia. Here is a true Alpine country ('The Monaro') where snow lies on the sheltered slopes almost all the year. and where the **ancient glaciers** have left huge piles of transported blocks (moraines) and scooped out the pretty lakes and tarns which fringe the main ridge. Except on the south-west, Kosciusko is not at all rugged, as may be realized from the fact that a motor route was constructed in 1908 almost to the top by gangs of 'unemployed', from whom, alas, Australia is not free. Many years ago a bullock dray carried up material for an Observatory on the summit, which has, however, been abandoned; and though an increasing number of tourists visit this land of flowing brooks—so rare in other portions of Australia—yet the uplands of the Monaro are chiefly inhabited by cattle.

Two of Australia's chief rivers flow down the western slopes of the Kosciusko massif. In many ways is the **Murrumbidgee River** interesting. One of its tributaries, Umeralla Creek, rises south-east of Cooma, less than 40 miles from the coast, and is 20 miles nearer Cape Howe than the Indi or Upper Murray. The State of Victoria in 1851 was defined on the north-east by a straight line drawn from Cape Howe to the *nearest* source of the River Murray. One can hardly blame one section of the Victorians for claiming that the portion of New South Wales—including most of the Riverina—south and west of the Murrumbidgee, by the terms of this Act should belong to Victoria! The Silurian limestones of the Upper Murrumbidgee are rich in picturesque caves which attract many visitors, and the route from Tumut by the **Yarrangobilly Caves** and Kiandra to Kosciusko and thence to Cooma is deservedly popular with Australian tourists.

Where the country becomes less rugged numerous small towns have arisen, such as Queanbeyan and Yass—and it is near the former that **Canberra,** the capital of the Commonwealth, is to be built. The site is close to the Inter-State Railway from Sydney to Melbourne, being about 200 miles from the former, and 400 from the Victorian capital. Of greater interest to the student of economics is the **Burrinjuck Dam** which has been constructed across the Murrumbidgee, 20 miles south-west of Yass, where the river passes through a gorge 800 or 1,000 feet high. A depth of 200 feet of water could be obtained, and the total capacity is very nearly equal to that of the Assouan dam on the Nile. This work is discussed in the section dealing with irrigation (Chapter XVIII).

The Victorian Highlands.

The southern division of the Cordillera consists of the Victorian Highlands (see Fig. 21), which run from west to east. An important group consists of the **granite masses** extending in a line from Glenelg to Kosciusko to the north of the present divide, which is formed of blocks of sedimentary rock running north and south. These diverse elements have been eroded to a more or less uniform level or *peneplain* (i. e. almost a plain) and re-elevated. The mountainous parts of Victoria are mainly formed by broad areas of **old peneplains** which are again being cut down to another base level by rivers whose erosive action has been renewed by the general uplift of the whole country. Professor Gregory has called the granite belt the Primitive Mountain Chain.

Eastern Victoria contains the greatest number (16) of peaks over 5,000 feet in the Eastern Highlands, such as **Hotham** (6,100), Feathertop, so called from its snow cap (6,300), and the **Bogongs** (6,500), while Kosciusko, in New South Wales, is only 10 miles over the border. This portion of Victoria is composed chiefly of granite and old palaeozoic rocks, so that it is rich in mineral wealth. South of Albury there is a flourishing **gold-mining district** around Beechworth; while the Ovens basin is noted for the winning of gold by **dredges** which lift the alluvial from the river bed. It is from this district that it has been proposed to irrigate the drier north-west portion of Victoria by means of an irrigation canal from the Upper Murray.

The upper waters of the Mitta Mitta, Ovens, and Goulburn flow through a rugged country in which farming is carried on successfully on the fertile soils of the river flats. The Ovens River district has almost the heaviest rainfall (44 inches) in Victoria, which becomes gradually drier towards the north-west as the highlands give place to plains (Wimmera), due to the raising above sea level of the ancient Murray gulf.

The central portion of the Victorian Highlands contains the best-known **gold-fields** in Australia. The four gold-fields of Bendigo (north), Ballarat (south), Castlemaine (east), and Maryborough (west) form a sort of 'Southern Cross' 60 miles long, from which 70 per cent. of the Victorian gold is derived. **Bendigo** is noted for its 'saddle reefs', which ensure permanency of yield to a greater extent than the more usual 'fissure veins'.[1] The slates have been folded so as to form Λ-shaped spaces at the summits of the upfolds (anticlines), and these have been subsequently filled in with auriferous quartz. Other quartz masses of a similar shape are generally found more or less perpendicularly below the first, and so the deposits somewhat resemble a pile of saddles one below the other. At **Ballarat** the well-known 'indicators', or regular bands of carbonaceous shale, show the richest portions of the quartz reef, since at their intersection a deposition of gold often occurs. This ore-deposit is described in detail elsewhere (pp. 187–8). But the district is by no means dependent on mining, for a great portion is cut up into prosperous farms, and indeed in most of the modern 'rushes' the neighbouring farmers have been the first in the field and naturally secured the best claims.

It is necessary to emphasize the plateau-like character of the Western Victorian Highlands. They are really stumps of old mountain ranges of various ages of elevation all of which have been rounded and flattened by long-continued erosion. **The Pyrenees,** between Ballarat and Ararat, are relics of the Primitive Mountain Chain which is flanked by alternating basins and plateaus rather than by ridges and narrow valleys. Basalt is common and its disintegration, which is more thorough and yields richer phosphate contents than do granites, enrichens the plains

[1] In fissure veins the ore occupies rents or fissures in the rocks. They are more irregular and uncertain than *saddle* reefs.

on lower levels. Ararat is the chief town in this western area, and is rich in gold mines, wheat, and vines.

Summarizing the physiography of the Victorian Highlands, one notes that the eastern portion is higher, more rugged, and has a heavier rainfall. Hence it is that the population curve bulges to the less rugged west as shown on the sketch-map (Fig. 21). Gold-mining is carried on throughout the Highlands, but the chief centres are around Ballarat and Beechworth. The drier, warmer western portions are more suitable for wheat and vines.

Other aspects of Victorian geography—such as general environment, wool, cattle, wheat, irrigation, &c., are treated in later chapters.

Tasmania.

There remains one well-defined area, undoubtedly a part of the Eastern Highlands, both geologically and biologically. The island of Tasmania is about the same size as Scotland, the width and length are both approximately 200 miles. **Bass Strait,** which separates it from the mainland, is 150 miles wide.

'An elevation of 300 feet would lay dry a tract of comparatively level country between Victoria and Tasmania, rising to a central ridge on the eastern side.'[1] It seems certain that this isthmus has been broken since pliocene times, for in the Beaconsfield gold-field fossil fruits of this age were found at the bottom of an ancient river valley, which is now many feet below the present deepest part of Bass Strait. A river cannot erode its bed below sea-level, so that the land must have been relatively 270 feet higher when the pliocene river deposited the fruits. Mr. Hedley [1] has shown that the **marine fauna** varies largely on each side of Tasmania, and has not yet completely mingled by way of the Bass Strait.

[1] *Proc. Lin. Soc. N.S.W.*, 1903, p. 878. Later soundings show a similar drowned isthmus (with King Island as a remnant) on the west. *Vide* Noetling; *Roy. Soc. Tas.*, 1912.

In the Straits are **King Island**—a valuable cattle-grazing region—and **Flinders Island.** On the latter lives a small half-caste population, the remnants of the lost Tasmanian negrito race.

Geology. Tasmania consists chiefly of older palaeozoic strata such as build up the Victorian Highlands. These have

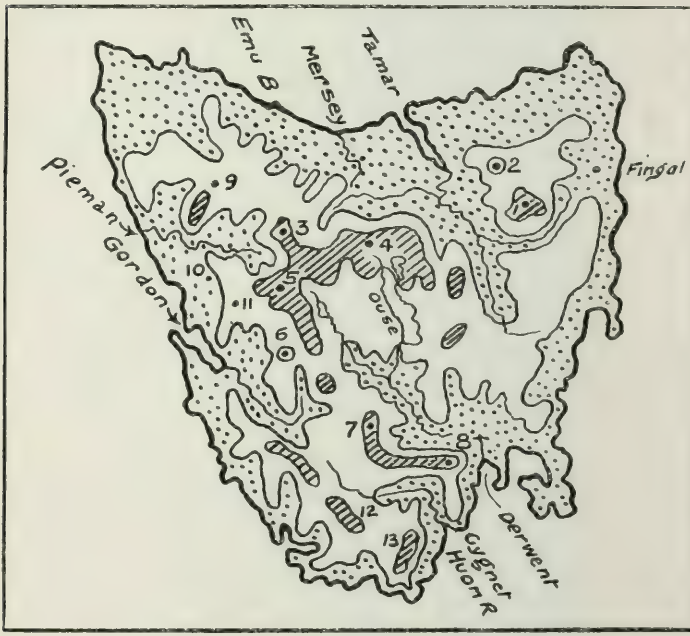

Fig. 23 a. Topography of Tasmania showing lowlands dotted. The 1000 and 3000 contours are given. Chief mountains are: 1. Ben Lomond; 2. Barrow; 3. Cradle Mountain; 4. Ironstone; 5. Eldon; 6. Frenchman's Cap; 7. Field West; 8. Wellington; 9. Bischoff; 10. Zeehan; 11. Lyell; 12. Arthur; 13. Hartz.

been penetrated by **granite masses** which on the east constitute the chief mountain axes, and in the north-west are associated with Mount Bischoff, Mount Zeehan, and Mount

Lyell, which are world-renowned mining-fields. Their mineral wealth is probably due to the interaction of the granites and sediments. During the time the **coal**

FIG. 23 B. Tasmania.

measures were accumulating in the New South Wales basin, a similar basin in Tasmania was being filled with marine sediments. Its axis extended in a north-west direction from Hobart, and it probably covered Central Tasmania. Profitable seams occur in isolated deposits, such as the Tasmanites and coal at Spreyton in the Mersey basin in the north. Somewhat later deposits of much greater value occur at Fingal in the north-east. But the most striking features in the geology of Tasmania are the huge **sheets of basalt** or allied rocks which have practically covered one-third of the island, including most of the coal basin, and form part of the 3,000 foot tableland of West Tasmania.

Topography. The chief block of highlands occupies the north central portion of the island. It rises to 5,069 feet in **Cradle** mountain, but more important is the broad stretch of the **central plateau** nearly all over 3,000 feet. It is truncated on the north and west forming the Western Tiers. To the south the Derwent and its tributaries have eaten away much of the plateau.

To the west and south lie other isolated portions of the plateau, such as Mounts Eldon, Field West, and Wellington. To the north-east is **Legge's Peak** (5,160), on the Ben Lomond massif, which is the highest point in the State.

Lakes and Rivers. On the Plateau are many large lakes. The **Great Lake** has an area of 30,000 acres, but is very shallow. St. Clair, Echo, Sorell, and Arthur's Lake are other depressions. There are three great valleys crossing the island (probably connected with ancient faults) and parallel to the west coast. These are occupied by the chief rivers. To the N.E. is the **Tamar-Macquarie** stream (with tributaries Esk and Meander). A parallel line of weakness ('lineament') seems to include the Pieman River on the west and the **Derwent** in the south-east. The latter receives the Clyde and Ouse rivers. The third 'lineament' contains the Gordon and **Huon** valleys.

A line joining Hobart to Emu Bay in the north-west separates approximately the extremely rugged western district from the fertile and prosperous eastern portion. The chief railway connects Hobart, the capital, with Launceston, the northern capital, and passes through a country which has often been compared to England, though its latitude is rather that of the Riviera. Tasmania is the sole Australian State blessed with an **abundant rainfall.** Indeed, the western portion has considerably more than 40 inches a year, due to the constant Westerlies rising over the tableland, and as the evaporation is not great, this is much more than is economically required. Here occurs the curious '**Horizontal Scrub**'[1], a tangled mass of boughs forming a kind of platform 30 feet from the ground.

The interesting forests of **beech** (*Fagus*) akin to those of Patagonia are confined to the regions in the west and around Ben Lomond, which receive over 50 inches of rainfall per year. In the west also are the **softwood Pines.**

The dense growth of the western jungles, for such they are, though in a temperate region, prevented the opening up of the west until the **Mount Bischoff** tin mines were discovered in 1871. For some time these mines yielded fabulous returns, especially after a tram line had been laid to Burnie. Thirty miles south the equally famous **Mount Zeehan** silver-lead mine was discovered in 1882, while in 1886, perhaps the richest district of all, **Mount Lyell,** was opened up, and now boasts that it is the largest copper mine in Australia. These famous mines are connected by a railway with Burnie on the north and Strahan on the west coast. In 1912 the Zeehan group produced silver-lead worth £309,000, Mount Bischoff tin worth £168,000, and Mount Lyell copper to the value of £385,000.

The area of Tasmania is only 1 per cent. of the whole Commonwealth, and this fact, combined with the rugged and wet character of the western half, has resulted in fewer **sheep** being raised than might have been expected

[1] *Anodopetalum biglandulosum*; see Geoffrey Smith, *Naturalist in Tasmania*, 1909.

from the situation of the island. The flocks of the mainland are regularly recruited from the cooler uplands of Tasmania, but the number of head has not altered since 1860, being about 1,750,000. They are most numerous around the Tamar and the rivers running into it.

It is recognized that Tasmania is pre-eminent in Australia as a **fruit-** and **vegetable-growing** country, though some of the larger states have a larger aggregate. In 1909, for instance, the value of the fruit (£450,000) and potatoes (£270,000) exported was nearly double that of wool, which reached £401,000. The chief orchards lie around the capital, Hobart, while large crops of **potatoes** are grown in the rich soils along the north coast to the west of the River Mersey.

An important engineering work has been completed whereby the waters of the Great Lake, in the centre of the island, are diverted into works one thousand feet lower on the upper waters of the Ouse. **Electrical energy** can thence be transmitted to almost every district in the State, and large metallurgical works are in operation near Hobart.

CHAPTER IX

THE CENTRAL LOWLANDS AND THE HIGHLANDS RISING OUT OF THEM

BETWEEN the Eastern Highlands and the Western Tableland lie the Central Lowlands. This is conveniently divided into the Murray-Darling Lowlands in the south-east, the Artesian Lowlands in the centre and north, and the South Australian Highlands and the Rift Valleys in the south-west.

THE MURRAY-DARLING LOWLANDS.

This is an approximately square area some 400 miles wide, and lies chiefly in New South Wales. The boundaries are fairly well defined on the south by the Victorian Highlands, on the west by the Flinders Range, and on the east by the Kosciusko and Blue Mountain Highlands; but on the north the southern boundary of the Great Artesian basin is not apparent from surface features. It has been mapped from borings, and runs along the Rivers Bogan and Darling to Bourke,[1] and thence in a general westerly direction past the Cambrian rocks to longitude 135° in South Australia.

There is no striking difference in the characteristics north or south of this admittedly arbitrary line except that the northern portion has an artesian water supply which is wanting south of the Bourke-Bogan line. Yet the Murray-Darling Basin is a fairly homogeneous geographic

[1] Later borings put the boundary farther south through Cobar to Broken Hill (cf. Kenyon).

unit which can be most satisfactorily considered apart from the remainder of the Central Lowlands.

There are three fairly distinct subdivisions, which are shown on the sketch-map (Fig. 24). (1) On the east is what may be termed the **Cobar-Wyalong Peneplain** of New South Wales, (2) in the centre are the **Western Plains,** whose southern portion is known as the **Riverina,** while (3) in the west is a large area of tertiary deposits which represent the **elevated sea-floor** of a broad estuary.

The Cobar-Wyalong Peneplain.

Dealing first with the Cobar-Wyalong Peneplain of New South Wales, it consists of the **foot-hills** of the Eastern Highlands, the eastern portion being some 1,500 feet high, and gradually sloping down to the Western Plains which reach the 500 contour line. As explained in a later section, the old palaeozoic sediments of the Eastern Highlands and its foot-hills are buried below the river soils and gravels of the Western Plains, but islands (inliers) of such old rock project at Mt. Hope and elsewhere and contain many **rich copper and gold deposits.** The chief mining-fields are **Cobar,** Mt. Boppy, Peak Hill, **Nymagee,** and Mt. Hope, north of the Lachlan, and Forbes, **Wyalong,** Temora, and Adelong, south of the Lachlan.

A large portion of this tract is within the wheat belt, but sheep are also largely pastured. (See pages 144 and 164.)

The Western Plains of the Murray-Darling Basin.

It is in the central division, the Western Plains, and especially in the Riverina between the Murray and the Murrumbidgee, that great irrigation developments are to be expected. **Wheat** grows well in the south-east. The

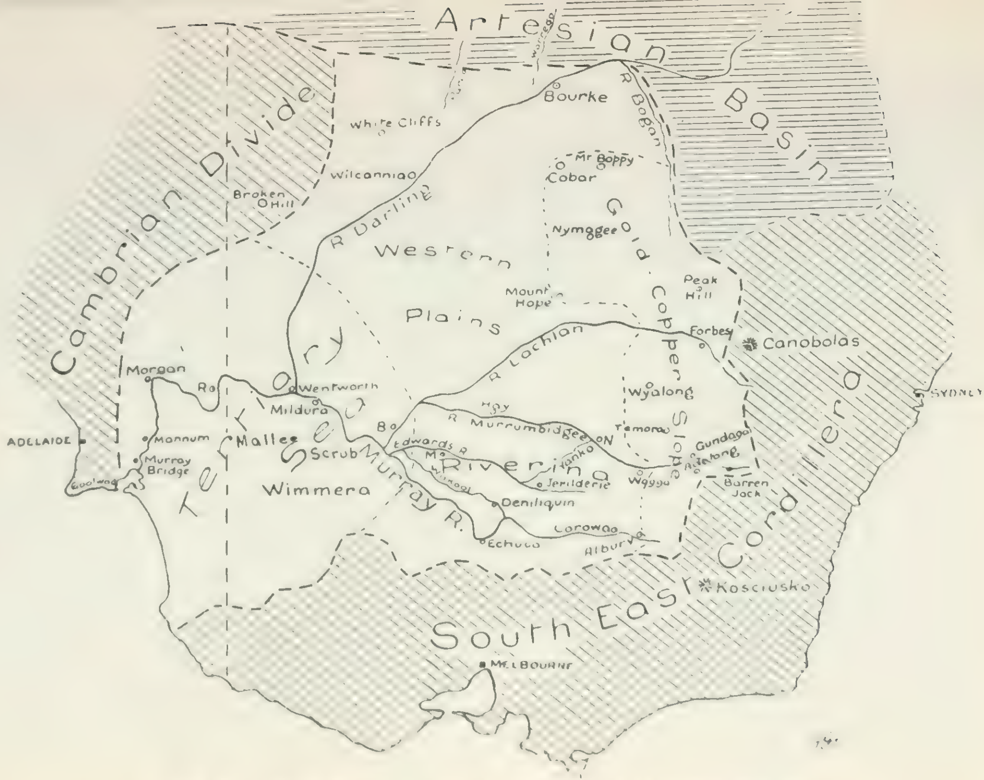

FIG. 24. The Murray-Darling Lowlands and their Subdivisions.
The South Australian divide is built up largely of Cambrian sediments.

quantity of rain falls off rapidly to the west, which is irrigated from the head-waters of the Victorian rivers and in New South Wales will be irrigated by the Burrinjuck scheme, which is described in detail on pp. 176–7. There is practically no mining, except for **opal** in the cretaceous sandstones at White Cliffs in the north-west, and, except for wheat in the south-east, little agriculture. The whole country is given over to the sheep (**chiefly merino**); and the cattle are gradually moving away north. Of the rivers of this area by far the largest is the **Darling,** which flows some 1,800 miles from its source to its junction with the Murray. In the south it dwindles to a series of water-holes during drought. Nearly all its water comes from Southern Queensland, for from Bourke to Wentworth, nearly 500 miles, it receives no tributaries; the Warrego and Paroo entering the main stream only during heavy floods. **Bourke,** the terminus of the Western Railway from Sydney, is a pastoral centre. **Wilcannia** is a river port collecting wool and mineral products which steamers carry to Murray Bridge and Morgan (South Australia), Goolwa (South Australia), or Echuca (Victoria), for transhipment to Adelaide or Melbourne.

The **Murray** itself is, however, much the most important stream, though it has not the length of the Darling. It is fed by the **snows of the Australian Alps,** and is the only river of the whole system which has never been known to cease running in dry seasons.[1] It rises near Mt. Kosciusko and forms the boundary between New South Wales and Victoria until just beyond Renmark (R. on Fig. 24), whence it flows across land which is wholly South Australian.

Albury, about a hundred miles from its source, is

[1] The Murray ceased to flow in the 1914 drought.

situated where it enters the plains. **Corowa** and Wahgunyah are twin towns through which a large portion of the trade of the Riverina passes to the capital of the southern State. The 'deep leads' or **alluvial gold** buried under ancient lavas extend beneath the Murray here and have yielded much gold. Wheat and vines grow well in the district. The **red-gum** timber is largely exploited between Corowa and **Echuca**, and grows only along the river belt. The latter town is an important river port and receives wool from the Darling and Lower Murray for transport to Melbourne. Here a private railway enters New South Wales and taps the Riverina as far as **Deniliquin**, the traffic being thus diverted to Melbourne. Indeed Melbourne is the natural outlet of the district south of Wagga, which town is roughly equidistant from Melbourne and Sydney.

The chief tributaries of the Murray, other than the Darling, within the Western Plains, are the Lachlan, Murrumbidgee, and Edwards.

The **Lachlan** drains the rich **gold-mining** country around Forbes and Temora already described. In summer it usually becomes a chain of water-holes, but a water conservation scheme now under consideration will, if carried out, vastly increase the resources of the land along its banks. These **black soil plains** are derived partly from the basalt hills of the Canobolas Mountains and are very fertile when sufficient moisture is available.

The **Murrumbidgee** is a finer river than the Lachlan, and having a more constant water supply rarely ceases running. After leaving Gundagai it flows through flat plains known as the **Riverina**, which extend southwards to the Murray. Several '**billabongs**' (Yanko, Wakool, &c.) connect the two rivers long before their junction near Balranald is reached. Some of the billabongs may be over a hundred miles long (e.g. the Edwards), and a local flood in the Murray may cause the water to flow *up* these billabongs for many miles. **Wagga**, Narandera, and Hay on the Murrumbidgee, Jerilderie, **Deniliquin**, and Moulamein on the billabongs, are all towns chiefly devoted to **wool**, though **wheat** is largely grown in the eastern districts of the Riverina.

There are also several important tributaries of the Murray in Victoria, such as the Mitta, Goulburn, and Loddon, but only their lower courses enter the area under discussion.

The Tertiary Area of the Murray-Darling Basin.

The third subdivision of the Murray-Darling area is the large extent of **tertiary deposits** which fill up the gulf into which the Darling, Murrumbidgee, and Murray once flowed by separate mouths. Except in the south-east this region is very dry, and settlements occur chiefly along the Murray, which plays the part of the Nile. Below Echuca this river is generally **navigable** at all seasons, but few towns of importance lie on its banks. **Mildura** in Victoria, near the junction of the Murray and Darling, is an irrigation colony where over a million has been spent on clearing land, pumping, &c. **Wentworth** is advantageously situated at the junction of two big rivers, and is an important river port whence wool is shipped to the railway at Morgan in South Australia. Some agriculture is possible although the rainfall is only 10 inches, for it falls almost wholly in the winter months. The **Renmark Irrigation** Works R. on Fig. 24) in South Australia support seven or eight hundred agriculturists. Several thousand acres watered by pumping from the river are planted with vines and fruit trees, and this oasis seems to be flourishing. **Morgan**, already mentioned as connected by rail with

Adelaide, is situated where the Murray makes a sharp bend to the south. For the remainder of its course no towns of note except Murray Bridge, where the Inter-State Railway crosses the river, are passed.

The outlet to the southern ocean of this huge river system—whose north-east limit is a thousand miles away—is **Lake Alexandrina**—a large, shallow lagoon, separated from deep water by shifting sand-banks which prevent navigation by any but the smallest steamers.

Enclosed within the rectangular course of the Lower Murray is an area of lowlands, extending towards the Victoria Highlands, with a rainfall gradually increasing to the south-east from 10 to 20 inches. Portions of this country are found to grow good **wheat** when cleared of the stunted gums which constitute the well-known '**Mallee Scrub**'. The rivers, which rise in the Grampians, do not in general reach the Murray, but lose themselves in the Mallee. The north-west portion of Victoria is known as the **Wimmera District**, and is traversed by belts of good country which will undoubtedly be of great value when the water conservation schemes are fully developed (see Fig. 21).

This tertiary basin is composed of various sediments, some being porous, so that they act as water-carriers and their supplies are utilized in **artesian bores** along the Pinnaroo railway. This underground water also augments the waters of the Murray.

At Millicent, in the extreme south-east of South Australia, this percolating water has formed **large swamps**. These are being drained by a gigantic scheme whose cost will be over half a million sterling. Probably the water in the Mount **Gambier Lakes** drains in underground from the higher land in Victoria.

Summarizing the geography of the Murray-Darling basin, it can be divided into (*a*) an *eastern* portion rich in gold and copper, and growing wheat where the rainfall exceeds 20 inches; (*b*) a *central* portion of plain country devoted to merinos, but with wheat in the south-east; and (*c*) a *south-west* portion, of which a large part near the Murray is an arid, undeveloped district, though irrigation colonies occur at Mildura and Renmark. The Wimmera District in Victoria is, however, a flourishing agricultural region watered by the River Wimmera and its tributaries.

CHAPTER X

THE SOUTH AUSTRALIAN HIGHLANDS AND THE RIFT VALLEYS

South Australian Highlands.

THIS is a well-defined geographical region consisting of the area of highlands between the Murray Basin and the Great Tableland of Australia. Not only is it of a totally distinct nature geologically from the rocks constituting the Tableland, but it is separated from the latter by a great

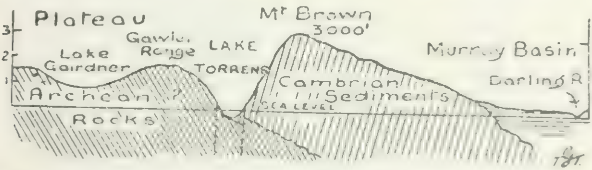

FIG. 25. Section across the Cambrian Divide, about the latitude of Lake Torrens, showing the Rift Valley occupied by the latter Lake.

depression or trough which, in Professor Gregory's opinion, constitutes a rift valley.[1] Lake Torrens is about 80 feet above and Lake Eyre 36 feet below sea-level, while Spencer's Gulf—one of the most important of the few gulfs penetrating the continental mass—is probably related to Lake Torrens in much the same way as the Gulf of Akaba is to the Dead Sea in the Jordan-Red Sea rift (see Fig. 25).

[1] A rift valley is due to the dropping in of the crust. It is not due to river-cutting, as are most valleys.

The main divide of these highlands lies somewhat to the west, culminating in **Mount Lofty** (near Adelaide, 2,334 ft.), Mount Razorback (near Burra, 2,834 ft.), and Mount Brown (near Quorn, 3,100 ft.) (see Fig. 26); near Blinman is **St. Mary's Peak** (3,900 ft.), and near Ajax is **Benbonyathe** (3,470 ft.).

None of the rivers are of importance, and in the north the water supply is obtained chiefly from wells sunk in the beds of the intermittent rivers. The lakes are all shallow sheets of **salt water.** In Yorke Peninsula salt is obtained from them, otherwise they are worthless. After heavy rains Lake Frome is almost joined to Lake Eyre, forming a temporary cordon of water which is marked on old maps as a vast horseshoe lake.

The geological factors mentioned above have led to an industrial isolation from the surrounding regions of a somewhat marked character. The Cambrian Highlands (including the Mount Lofty and Flinders Ranges) lie in the course of the strong westerly winds in winter. They have therefore a better rainfall (see Fig. 26). The main settlement in South Australia has accordingly taken place from Beltana to Eyre Peninsula on the west and to Morgan on the east. The chief industries in 1913 were wool-growing (£2,300,000), wheat-growing (£3,380,000), copper-mining (£489,000), and wine-growing (£100,000), and with the exception of a portion of the wool, almost all these products are obtained from the Highlands or the districts bordering thereon. The heaviest rainfall occurs round Adelaide on the slopes of the Mount Lofty Ranges. Here the **vineyards** are planted whose wines are becoming favourably known all over the world. Clare and Tanunda are two of the most famous cellars, both being to the north-east of Adelaide.

The ancient slates and limestones constituting this

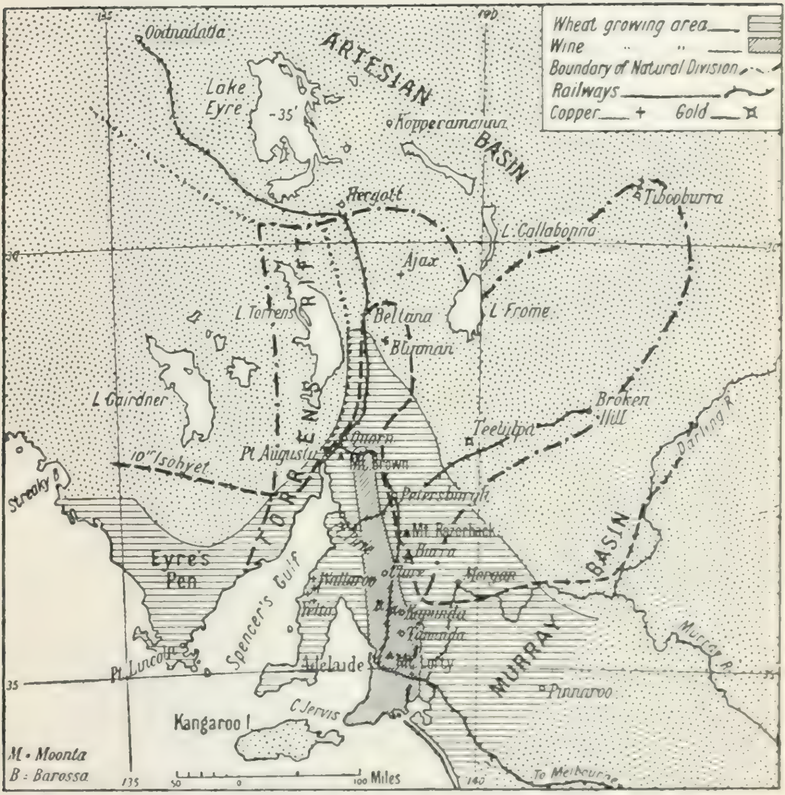

Fig. 26. The South Australian or Cambrian Highlands and the Torrens Rift Valley.

Cambrian area are much folded and have been penetrated by ore-bearing thermal waters. The mines at Moonta and Burra (80 miles north-west and north-east respectively from Adelaide) were once the chief sources of **copper** in Australia. The former is still very important, and copper 'shows' occur throughout the Cambrian area. Gold has not been of much importance, for South Australia produces less than 1 per cent. of the Australian yield. On the eastern edge (in New South Wales) is the phenomenally rich **silver-lead-zinc** deposit of **Broken Hill.** Excluding the capitals, this town is the fifth in Australia, although situated 200 miles from the coast in a desert region with less than 10 inches of rainfall per annum. The mine and its environment are discussed in a later section (pp. 183-6). North of Broken Hill are two **gold mines** in the same formation, at Tibooburra and Mount Brown. Apart from mining, there is little profit in this arid tract, though **sheep-rearing** can be carried on successfully on large stations where each sheep can be given a wide enough grazing-ground—say 40 sheep to a square mile.[1] It is not the direct lack of water so much as the lack of food during drought which destroys flocks.

It is to **wheat,** however, that South Australia chiefly owes her prosperity. The wheat line coincides fairly accurately with the 13 inch [2] isohyet (see Fig. 26), the rain falling chiefly in those months when it is most needed, so that the total supply, though low, is sufficient. The three peninsulas, Eyre's, Yorke, and Mount Lofty, are included in this area and produce perhaps the best selling wheat in the world. So also the 20 inch isohyet bounds the chief viticultural area, while the 10 inch isohyet is the limit of

[1] D. J. Gordon, *The Central State*, p. 44, gives valuable figures in this connexion.

[2] The wheat belt is slowly spreading into drier regions. With careful culture eleven and even ten inches is found sufficient.

economic wool-growing, except in the case of extremely large holdings where expensive water conservation can be undertaken.

The country to the **west of Spencer's Gulf** is progressing rapidly. In 1916 there were 700,000 acres in cultivation, but perhaps 4,000,000 are suited for wheat. There are 400 miles of railway, reaching inland from **Port Lincoln** (see Fig. 57). Half a million sheep are grazed on this coast from Port Augusta to Fowler's Bay. All this is possible with a rainfall of only about 15 inches—because it is one of the **most reliable rain regions** in Australia.

The Torrens Rift Valley.

This district is of practically no industrial importance except at the head of Spencer's Gulf, where two flourishing ports, Port Augusta and Port Pirie, are situated. **Port Augusta** has a fine harbour where the products of the northern portion of South Australia proper are shipped. Wool, wheat, and copper ore, as might be expected, are the chief exports. Some gold from Tarcoola is also shipped here. It is the eastern terminus of the Trans-Continental Railway.

Port Pirie is the second town in South Australia, the population being largely engaged in **smelting** the Broken Hill ores. During the wheat season immense quantities are shipped at this port.

The inland portion of this area is arid and undeveloped.[1] A low gap—nowhere reaching to 500 feet—leads from Lake Torrens to Lake Eyre.

[1] The physiography of this barren region is briefly described in Gregory's *Dead Heart of Australia*.

CHAPTER XI

THE ARTESIAN REGION

A WELL-DEFINED geographical region of Australia is coincident with the Artesian Region. It may be divided into two parts (see sketch-map, Fig. 19) which may be termed for convenience of reference the Lake Eyre Division and the Eastern Division. The boundary between these two areas almost coincides with the 10 inch isohyet, so that one may broadly term the Lake Eyre Division the Desert moiety and the Eastern Division the Pastoral moiety.

The geological structure of this region being discussed at some length in a later section (Chap. XVI), it will be sufficient to remark that it consists largely of a series of soft sedimentary rocks, capped occasionally by harder barren sandstones—the Desert Sandstone.

The Eastern or Pastoral Artesian Region.

The Eastern Division extends some 1,200 miles from the Gulf of Carpentaria to Dubbo on the Macquarie River in New South Wales, and is about 300 miles wide.

The northern portion around the Gulf consists of a low-lying country—probably the elevated bed of the gulf adjacent—with a rainfall of 20 to 40 inches. It is watered by numerous rivers. **Normanton**, the chief town, is partly supplied with water by an artesian bore. Behind the mangrove swamps of the northern margin is an important **cattle-grazing** district. The chief industries are, however, connected with mining, much gold being obtained at **Croydon** and copper at **Cloncurry.** These ore deposits occur in 'islands' of older rock, projecting through the artesian water-bearing strata.

To the south of this Gulf country the land rises considerably, and a strip of about a thousand feet above the sea extends south to the head-waters of the Paroo and other northern tributaries of the Murray, whence it gradually slopes down to 500 feet along the southern boundary of the artesian basin. It is important to note that this portion of the Artesian Basin lies almost wholly in the 10 to 20 inch rainfall area, so that except in the S.E. corner, where some wheat is grown, there is nothing to compete with the **pastoral industry.** Hughenden, Winton, Barcaldine, Charleville, and Cunnamulla are all centres of sheep and cattle districts connected by railways to one of the ports, Townsville, Rockhampton, or Brisbane (see later chapters).

The northern portion of New South Wales is included in this artesian area. Here, in addition to pastoral products, large quantities of **wheat** are grown round Narrabri, Moree, &c., and indeed as far north as Roma, in latitude 26° 36′. In the whole of this large area over two thousand **artesian bores** have been drilled and are of immense value for watering stock, though it is doubtful if they are an economic source of water supply for irrigation. This question is, however, discussed in Chapter XVI.

The Lake Eyre Basin or Desert Artesian Region.

The remaining division of the Artesian Basin comprises the lowlands drained by the rivers Diamentina, Barcoo, &c. The lowest portion of the area constitutes **Lake Eyre**, of which the southern arm usually contains salt water, while the remainder is a vast salty plain formed from alluvium carried down by the large rivers which now enter it only in flood time. It is situated within the 10 inch isohyet,[1] and though many pastoral areas have been occupied, almost all are now deserted. Professor Gregory has named this region graphically and forcibly, '**The Dead Heart of Australia.**' His book gives a clear picture of the region at midsummer, while the writer found in February, 1906, the same conditions of terrific heat and deserted sheep-runs.

During good seasons, such as those of the eighties, this area (150,000 sq. miles) can support thousands of sheep, but it is difficult to see how the inevitable period of dry seasons can be tided over. The artesian water supply will not prevent the **shortage of food**, such as salt-bush and blue-bush, and conservation of flood waters in this level area on any large scale is almost an impossibility. Moreover, drought is the rule rather than the exception, and as the more northern districts of the territory appear to be much better country it seems probable that the Lake Eyre Basin will be one of the last regions of Australia to repay settlement. Since the geological formation is late mesozoic there is little likelihood of valuable mineral deposits being discovered, since such usually occur in palaeozoic rocks.

Opals occur in the east near Winton (Queensland) and at White Cliffs in New South Wales, but the huge arid settlements of Broken Hill (silver-lead) and Kalgoorlie (gold) can never be paralleled in the Lake Eyre Basin.

Professor Gregory has disposed of the project to increase the rainfall of this region by **filling Lake Eyre** with sea water. It is 39 feet below sea-level, but the necessary

[1] Kanowana (100 miles east of Lake Eyre) has an average of 4·24 inches (in 20 years). Oodnadatta has 4·68 inches with a similarly long record.

canal (260 miles long and probably 1,100 feet wide and 100 feet deep) would cost, it is calculated, about £740,000,000. Moreover, it is probable that in thirty years the whole lake bed would be choked with salt derived from the evaporation of the sea water!

The value of the artesian water in keeping open the great stock routes is discussed in a later section (pp. 155–7).

CHAPTER XII

THE WESTERN TABLELAND

The last physical region with which we have to deal is much the largest. It comprises about **54 per cent.** of the continent and includes the whole of Western Australia and most of South Australia, except those portions of the latter state which have already been described under the heads of the Lake Eyre Basin and the South Australian Highlands.

This vast region is by no means so important economically as the Central Lowlands, and only supports about **6 per cent. of the population** (250,000 out of 4,000,000). It consists in the south of an enormous area of **very ancient rocks** (such as gneisses, schists, and quartzites), which are probably of pre-palaeozoic age. To the north of latitude 25° S., the rocks seem to be largely of palaeozoic age (Talbot). They form a plateau about 1,000 feet in height (Leopold Range) in the Kimberley district. No rivers water the interior, but along the coast, especially in Northern Territory, there are several **fine waterways,** such as the Roper and Victoria.[1]

It will be recognized that there are no dominating physical features to assist subdivision of this large area, except it be the Central Highlands in the east, which form one division. Since this tableland extends through almost 25° of latitude it is obvious that it is subjected to very different meteorological conditions. Accordingly the most

[1] The Roper can be navigated for 90 miles by vessels drawing 14 feet; and the Victoria for 100 miles by launches.

satisfactory divisions are the **south-western temperate region**, the **north-western tropical region**, and the **central desert** with its enclave[1] the **Central Highlands** (see Fig. 27).

Fig. 27. The Western Tableland Region.

The North-Western or Tropical Tableland.

The northern tropical region extends from the Gulf of Carpentaria round to Shark Bay on the west, and has an average width of about 400 miles. The towns in this vast territory number about a dozen, being with very few

[1] *Enclave* means a well-defined region *enclosed* by another.

exceptions either settlements around the stamp batteries on a **gold-field,** or ports leading to them.[1]

In Northern Territory four industries occupy all the inhabitants,[2] of whom some eighteen hundred are European. In 1913 the chief products were: **cattle,** 418,000 head; **tin,** £26,000; **gold,** £13,250; and **pearl-shelling,** £6,000. The coast is low and flat, and 100 miles inland at Yam Creek it is only 300 feet high. Still farther inland there is a series of low ranges which do not exceed 1,000 feet, though they are extremely rugged. There are higher elevations in the little-known Arnhem Land.

These low ranges contain the **mineral deposits,** which give employment to one hundred Europeans and about four hundred Chinamen. They are all near Pine Creek. Brock Creek produces gold, Mount Wells and Mount Todd produce tin, wolfram comes from Yenberrie, and copper from the Daly River.

Vegetation. From north to south there is considerable variation in rainfall, ranging from 60 inches to 6 inches. It is entirely a **summer rain,** and this makes for a more uniform type of flora than the diversity of rainfall would suggest. **Eucalypts** are the dominant trees. Even in the north there are no true rain-forests, while in the south even in the sand-ridge country there are always numerous **mulga** trees.

In the north the limestones carry good feed and finer trees than the **sandstones,** but unluckily the latter formations preponderate, while rich volcanic soils are almost absent. In the south the sandy formations are

[1] A graphic picture of life on one of these Territory stations is given by Mrs. A. Gunn in her book *We of the Never-never.*

[2] At the end of 1912 the population was estimated at nearly 2,000 Europeans, 1,300 Chinese, 1,200 semi-civilized Blacks, and possibly 50,000 wild Blacks.

more useful than the clay-pan country (which often alternates with them).

Cattle and horse rearing will be the main industry, other than mining, for many years to come. There is certainly very good land available for this purpose in many portions of the hinterland,[1] especially around the head-waters of the Victoria River in the west, and from the head of the Roper to Camooweal in Queensland. In 1915 there were 483,961 cattle, 19,957 horses, and 57,827 sheep in the Territory, obviously not a tithe of those which the country could support, judging by the distribution in Queensland, where a somewhat similar area between the same rainfall lines gives food for three million cattle, half a million horses, and fourteen million sheep. A railway 145 miles long connects Pine Creek and Darwin, and is being continued to Katherine, and thence the overland telegraph runs south through good cattle country for 400 miles.[2]

Agriculture has made little progress. **Rice** suitable for chaff and for milling has been grown. **Maize, cow-peas,** millet, and sugar-cane have also done well. There is no hope of rivalling other tropical regions in crops such as cotton, tea, and coffee, for labour is unobtainable (Knibbs, 1917). Only **ten farmers** are settled in the whole region.

In Western Australia somewhat similar country occurs as far south as Shark Bay, where conditions more favourable to white settlement commence. All along this coast **pearl-shell** is obtained; the head-quarters of the fleets being at Broome, Roeburne, and Condon (see pp. 219–20).

[1] *Hinterland* is a term for the region immediately *behind* the coastal region.

[2] In the magazine *Life* (published in Melbourne) for March, 1907, there is a map of the Northern Territory in which the district north of 20° is given as good pastoral country.

Another profitable undertaking is the gathering of guano, chiefly from the Lacepede, Dampier, and Abrolhos Islands.

The coastal plain is wider at the mouths of the Ashburton and Gascoyne rivers, but no important agriculture is carried on north of Shark Bay. Several well-defined **gold-fields** occur in this division. **Kimberley** lies in the north of the State in the hilly country (King Leopold Ranges) dividing the basins of the Fitzroy and Ord rivers. Hall's Creek is the chief centre and is reached via Derby or Wyndham. The whole population is less than a thousand, though half the **cattle of the State and many sheep** are raised here. Near Derby is Broome, where the cable from Java is landed. It is an important pearling centre, a large cattle-port, and the chief town in the north-west. A large **artesian basin** is tapped at Broome, one bore giving 14,000 gallons a day.

To the south, across the western fringe of the Great Sandy Desert, is the **Pilbarra gold-field.** Here again the mines are scattered, Marble Bar being the chief centre. They are reached from the ports of Cossack and Condon. Sheep are more plentiful in this district, especially near Roeburne and Onslow.

The southern 10-inch annual rainfall line which runs from Shark Bay south-eastwards to Southern Cross has been chosen as the northern boundary of the *temperate* region, since the country changes greatly in character to the south of this. A considerable extent of hilly land outside this, but *south* of the tropic of Capricorn, can be included with the tropical region, for it differs little from the other districts already considered, except that it has a rainfall of less than 10 inches.

The **Murchison gold-field** is situated here. A railway connects the chief centres Nannine, Cue, and Mount Magnet with the coast at Geraldton. The population of the district is some four or five thousand. Notwithstanding the low rainfall there are some large sheep runs near Carnarvon, while **cattle** are grazed in large numbers near Peak Hill.

The South-Western or Temperate Tableland (or 'Swanland').

To the west of the 135° meridian, close settlement is confined to the south-west corner of the continent, which is the only district where **good agricultural land** suitable for white labour occurs. This is included in the region with which we are now dealing, which extends from the 10-inch mean annual isohyetal line to Cape Leeuwin (see Figs. 27 and 51).

The western coast is flat and low, but the **Darling Escarpment** rises rather abruptly from it to a height of about 800 feet, but nowhere exceeds 1,500 feet. Inland is a **forest-covered** plateau gradually attaining a general elevation of 1,000 feet. In the east the timber gives place to scrubby trees and bushes, and these in turn merge into the barer desert country.

In the south the Blackwood and **Stirling Ranges** are more important. The latter, near Albany, rises abruptly to 3,500 feet and so is a very prominent landmark. The coast-line along the Great Australian Bight is very inhospitable and bounded by high cliffs, but inland from Eucla good pastoral land is reported, though permanent water is absent.

This Southern Temperate Region consists of two kinds of country. First, a triangular area of about 50,000 square miles (the same size as England), with an average annual rainfall of over 15 inches, is **rich in timber** and eminently suited for agriculture. Secondly, to the east is a long strip with between 10 and 15 inches of rainfall which is suitable for **pastoral purposes** and, as in Eastern Australia, grows much wheat along its wetter margins (see Fig. 51).

The industrial features of the south-west district somewhat resemble those of Victoria. There is heavily timbered country near the coast, and also some coal and metals (tin in this instance). Inland the country rises considerably to dry plains beyond, which are given over to sheep. Timber is the most important product and during 1901–6 the timber cut was estimated to be worth £5,250,000, being considerably more than in any other State (pp. 206–8).

More than half the **sheep** of the State are grazed in the south-west corner, especially near Geraldton and Katanning. They cannot penetrate so far from the railways as can cattle, which are found to a much greater degree in the arid interior. The **dairies** are all in this corner of the State, where there are 28,000 dairy cattle.

Interesting features of the pastoral country are the **rabbit-proof fences.** The chief of these extends from the north coast near Condon for a thousand miles to Hopetoun on the Bight. Another earlier fence runs from Hopetoun to Yalgoo and thence down the Murchison valley. These fences are inspected continually, but the rabbits have lately broken through and reached the Albany districts.

Wheat has quadrupled in amount in the last ten years, and in 1916 reached 18,000,000 bushels. It is absolutely **controlled by the rainfall**, almost wholly growing between the 10 and 30 inches (of *winter* rainfall). York may be taken as the centre of production, and thence it spreads north to Geraldton and south to Katanning. A great development of **railways** has lately occurred in the wheat belt. The new northern line from Mullewa to

Northam and the five branch lines from the southern line were all primarily built to open up this belt.

There is an important **orchard belt** in Swanland. Apples grow splendidly in the Karri region, south of Bunbury. Many other orchards are scattered through the Jarrah belt (see Fig. 51); oranges also thrive here. The **vine** country is chiefly in the district between Bunbury and Gingin.

One little-known industry is that of **whaling.** The chief stations are at Albany and near Onslow.

Mining, except for gold, is not of great importance in West Australia. Except for a coastal strip of late sediments (post-palaeozoic) the State consists of very old rocks (see map, Fig. 5), such as gneiss and schists, and in these metalliferous veins are to be expected. The **gold-fields** are discussed in Chapter XIX. Copper (£60,000 total in 1912) occurs chiefly at Pilbarra, and *tin* at Pilbarra and Greenbushes (£70,000 total value in 1912). A small but important **coalfield** of mesozoic age occurs at Collie in the south-west. It is not suitable for export, being hydrous and ashy, but is used locally. The coal obtained in 1912 amounted to 295,000 tons, valued at £135,857.

The Central or Desert Tableland.

This last division of the Tableland Region is rectangular in shape, about 1,000 miles from west to east and 600 from north to south. The Lake Eyre Basin is of the same arid character, and with this addition the desert may be described approximately as occupying the rectangle between Condon and Cloncurry on the north, and Southern Cross and Broken Hill on the south.

It was naturally the last portion of Australia to be explored, for though the eastern portion was traversed by Sturt, Stuart, and others before 1863, it was not till Forrest and Giles crossed the western desert in 1874–5 that the character of the centre of Western Australia could be adequately described. At a much later date the large intervening unexplored area was crossed in a north and south direction by Carnegie (1896) and others.

The South Australian portion of the arid region is by no means wholly barren, but consists of a series of belts of fair pastoral country, alternating with stony areas or spinifex and mulga scrubs. The best areas would seem to lie near the MacDonnell Ranges, but north of this, near Powell's Creek, and south, near the west of Lake Eyre, are other regions suitable for stock in good seasons. On the other hand, the arid region of Western Australia is largely an uncompromising desert.

Carnegie (1896) left the gold-fields near Laverton to strike across the continent in a NNE. direction, in the hopes of finding gold-bearing or pastoral country in the great desert. Travelling over a long stretch of dry country, during which journey the camels were without water for 13½ days, they reached a soakage near Alexander Springs (see map on page 27). Beyond, a few low sandstone ranges and hills were found, and occasionally in the valleys, belts of bloodwood and a few shrubs edible by camels, but most of the country was a continuous **waste of sand ridges.** They reached Hall's Creek, and returned south along the South Australian border. The sand ridges in this district were so frequent that in eight hours' travelling eighty-six of them were passed over. **No permanent water** was found after leaving Sturt's Creek (100 miles south of Hall's Creek), and the impracticability of a stock route being opened in this direction between Kimberley and the North Coolgardie Fields was proved beyond question. It was, moreover, clearly shown that the desert they traversed contained **no auriferous country,** with the possible exception of small and isolated patches. The vegetation along the course of this journey for a distance of 700 miles consisted chiefly of so-called spinifex. Carnegie describes it fully in his interesting book.[1] As it is characteristic of one-third of Australia, an abstract of his account of it is given here.

False Spinifex (*Triodia irritans*) grows in round isolated hummocks 1 to 3 feet high. These hummocks are a dense mass of needle-like prickles, and from them grow blades of very coarse grass to a height of sometimes 6 feet. It serves in a measure to bind the sand and protect it from being moved by the wind. In Northern Australia spinifex is in seed for three weeks, then forming a most excellent food for horses, and fattens almost as quickly as oats. For the rest of the year it is useless.

Water supply. The hydrography of the inland region can be gathered from Talbot's report of his survey of **Canning's stock route** (see Fig. 27). Some fifty wells were sunk along a line from Wiluna to Hall's Creek. From Wiluna to Weld Spring sand-ridge, clay-pan, and mulga country occurs, but natural water-holes are to be found every twenty miles or so. For the first half of the stock route the wells were sunk to an average depth of 36 feet. These yielded about 1,000 gallons per hour, though the flow varied greatly.

In the northern half of the route Canning made use to a greater extent of cleaned-out **native wells** and rock-holes. Talbot concludes as follows: 'Although at some future time the country along the **Sturt River** may become settled, that along the stock route to the south is never likely to become occupied by pastoralists.'

Two districts in this Desert Region deserve special mention, the MacDonnell Ranges in the east and the

[1] D. W. Carnegie, *Spinifex and Sand*, 1898.

Western Australian gold-fields in the south-west. The southern gold-fields district is described from an industrial point of view in two later sections of this book (Gold and Irrigation in Western Australia). Until 1887 it was a barren desert such as has been already described, but in that year the **Southern Cross** field was discovered, and in 1892, partly in consequence of the report of the explorer Lindsay (1891), the **Coolgardie fields** were discovered. Here the only water supply at first was obtained from small 'soaks'. Later portable condensers were used to separate the salt from water derived from holes dug in the salt lakes. Before the railway was opened the Government constructed tanks along the route near granite outcrops which served as collecting-grounds after occasional rains. Each of these held about a million gallons and cost some £3,000. This precarious supply is now superseded by the wonderful **waterworks** described on p. 179. While the gold *reefs* are worked on much the same plan as elsewhere, ordinary sluicing methods cannot be applied to the gold occurring in the surface soil. This is won by '**dry-blowing**'. The simplest method is to allow the alluvial material to fall from one dish to another held below it, the wind blowing away the finer, lighter particles, and gradually concentrating the gold. For about 250 miles, from Dundas northwards to Mount Margaret (see Fig. 44 A), there is an almost continuous series of mines.

In 1914 about 50,000 inhabitants—or nearly one-fifth of the total population of the State—inhabited these interior mining-fields.

The Central Highlands.

In the centre of the continent lies an area of elevated land—**the MacDonnell Ranges**—the physical characteristics of which are better known than those of many more

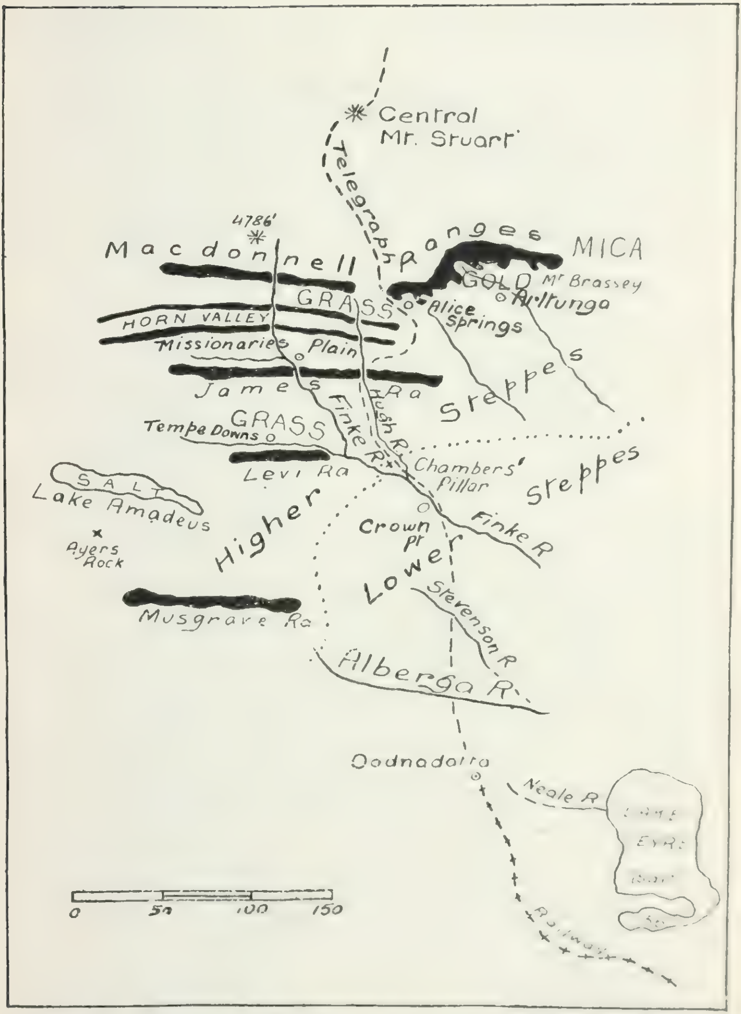

Fig. 28. The Central Highlands of Australia (based on the Report of the Horn Expedition). The east-west ridges constituting the MacDonnell Ranges are shown in black.

accessible regions. This is due to the efforts of the **Horn Expedition** of 1894, which consisted chiefly of well-trained scientific men.[1]

Though the country was found to be extremely interesting to geologists and biologists, it must be admitted that the reports have strengthened the conviction that the centre of Australia is of very little value from an economic point of view. Professor Spencer writes that he 'hoped to find well-watered and fertile valleys. . . . In reality the ranges form bare and often narrow ridges separated from one another by dry and sandy scrub-covered flats.'

The region between Lake Eyre and the Levi Ranges (see Fig. 28) consists chiefly of **'gibber' plains**—which are covered with the more resistant fragments (gibbers—the 'g' is hard) of the cretaceous sandstones—and of arid loamy plains free from gibbers; both of which support a sparse saltbush flora. These are called by Professor Spencer the Lower Steppes.

As soon as the northern boundary of the cretaceous area is passed (near Chambers' Pillar) a striking difference appears in the configuration of the country. The rocks now consist of Lower Silurian sandstones and limestones which have been folded at some ancient period into a series of **ridges and troughs** running east and west. These corrugated strata have been subjected to a movement of elevation in quite recent geological times, and the rivers acting on the erstwhile planed surface have cut out the extraordinary series of gorges and lateral valleys which form so striking a feature of the region.

The **Finke River**, rising north of the chief ranges, has kept to the course it occupied prior to the uplift. It runs

[1] A full account (in four volumes), edited by Professor Spencer of Melbourne, has been issued by Dulau & Co. (1896). The expedition left Oodnadatta in May and returned in August, 1894, i.e. during winter.

right across the steep ridges of silurian sandstone which are the relics of the more resistant beds in the originally level pre-uplift surface.[1] The tributary streams (Horn Valley, Palm Creek, &c.) have eaten their way along the softer or less stable beds parallel to the axes of the folds.

To their unusual morphological features these ranges owe the permanency of their water supply. For it is protected from rapid evaporation in the **deep gullies** and gorges (some of which, though 200 feet deep, are only a few feet wide), while in the surrounding plains the rainfall evaporates almost as soon as it falls.

Permanent pasture, however, is rare, and the chief **cattle areas** are near Alice Springs and Tempe Downs (see Fig. 28). Professor Spencer writes: 'Of late years drought and low prices have combined to render the enterprise of those who have attempted to utilize the land of the far interior a somewhat hazardous undertaking.'

To the west, as soon as the ranges are left behind, the monotonous sandhill, mulga, and spinifex country commences, and extends through Western Australia to Coolgardie. The so-called **Lake Amadeus** (see Fig. 28) is usually a sheet of salt, about half an inch thick, and is obviously quite valueless for water supply.

The northern portion of the MacDonnell area consists of much older rocks, such as gneisses and schists. These are probably of archaean age and allied to those covering a large part of Western Australia. Associated with them are certain 'dykes' of granite, which yield a valuable supply of the mineral *muscovite* (**white mica**). The chief mica mines are situated near Mount Brassey in the north-east of the Ranges, where plates of mica 6 feet across have been obtained. They are sent by camel to Oodnadatta and are exported for use in electrical works. In the same region is **Arltunga**, a gold-field which promised well some

[1] It is thus a fine example of an 'antecedent' river.

years ago, but it is heavily handicapped by its situation and environment.

It is to be feared that neither the cattle, mica, nor gold will lead to the prosperous settlement of Central Australia. The low rainfall (averaging only 6 inches per year over the greater part of the area) will prohibit extensive pastoral occupation, while the 200 miles of transport to the railway at Oodnadatta—and thence 600 miles to Adelaide—will prevent the exploitation of any but very rich mineral-fields.

SECTION IV. A SPECIAL EXAMPLE OF GEOGRAPHIC CORRELATION

CHAPTER XIII

RELATION OF ENVIRONMENT AND OCCUPATIONS IN SOUTH-EAST AUSTRALIA

A BRIEF sketch of the way in which the physical conditions have governed the growth of population in South-East Australia will serve as an introduction to the second part of this work, which gives detailed accounts of the various industries.

From the descriptions in preceding sections it will be evident that the geological structure of a country controls its physical features and its mining industries; that climatic conditions (in Australia more particularly rainfall), as well as suitable soil, determine which regions are barren or pastoral or agricultural.

The logical sequence is therefore—(1) Geological Features; (2) Topographical Features; (3) Climatic Conditions; (4) The Resultant Vegetation and the Consequent Industries.

Referring to the geological section drawn across New South Wales (see Figs. 22 and 29), it is seen that the dominant formation is a series of folded slates and sandstones, of Silurian age. These, however, are hidden from sight over half the section by two large deposits; the tertiary plains in the west, and the coal measures (PP) near the coast, each of which occupies a basin formed in the older sediments.

On the western side, the great Tertiary Murray basin is bounded by a raised rim of Cambrian and older rocks which separates it from the South Australian gulfs. On the south the structure of the rim is the same as in New South Wales. But to the south-west the Tertiary basin reaches the sea and forms the coast-line for 200 miles.

Probably at the close of the carboniferous period a longitudinal depression was formed where the Sydney coal basin is situated, and in this was deposited the coal measures (PP in Fig. 29). Later movements led to the infilling of brackish or freshwater lakes by trias sandstones at Sydney, at Grafton, and along the southern edge of the Victorian Highlands.

The north-west now began to receive the enormous deposits of sand and mud which constitute the artesian basin. Finally, an upward movement led to a great increase in the land surface of South-East Australia. The marine sands in the south-west contain numerous fossils, proving that not very far back in geological time the Murray and Darling flowed independently into a huge gulf extending at this corner as far as Swan Hill and Menindie.

Besides these sediments there are various eruptive rocks of considerable importance. The great granite masses are chiefly noticeable in the Gawler Ranges (S.A.), in the Victorian Highlands, and especially near Kosciusko, and New England in New South Wales. (They are shown by crosses on Fig. 29.) Much later volcanic flows are very important in Western Victoria, in the Darling Downs (Q.), and in the great Plateau of Tasmania.

In Figs. 20 and 21 the main topographical features are represented, contours of 1,000 and 3,000 feet showing clearly the arrangement of the elevated land. The influence of the geological structure is at once apparent.

The later tertiary and secondary sediments (Fig. 29) are seen to constitute the western plains. No great earth-movements have folded these later sediments into ridges and hollows. The land slopes gradually from north-east to south-west, and is so flat that many of the rivers in flood-time cover many square miles of country, while the water of one tributary may flow into the next *across* country instead of into the main river (cf. Warrego and Paroo in South Queensland).

Still comparing Figs. 20 and 29, the 1,000 foot contour is seen to agree remarkably with the boundary between the primary and later sediments. In fact, the originally rugged country between Broken Hill and the Eastern Highlands has undoubtedly been filled up and smoothed over by means of these tertiary and secondary strata. Here and there 'islands' of the older slates project above the enshrouding strata, as at Milparinka (in north-west of Fig. 29) and in the Cobar peneplain, revealing the character of the bed rock.

The solid core of granite in New England and Kosciusko has determined to a large extent the position of the two main massifs in the States.

On the other hand, the Blue Mountains are largely due to a fold of late date, which was accompanied by outpouring of basic lava (basalt), the soils of which are of great economic importance.

The Hunter Valley furnishes one of the best examples of the interaction of environment and life. The Hunter River has eroded its path in the coal measures at a more rapid rate than other coastal streams which have harder rocks to work on. A gap in the Eastern Highlands near Cassilis has been formed (see Fig. 20). The rainfall of the low-lying Hunter Valley is comparatively slight (see Fig. 30), and the flora of the drier west has migrated over the divide and is found in the Upper Hunter Valley, and nowhere else to the *east of the Main Divide*.

In Victoria the Highlands are entirely built up of

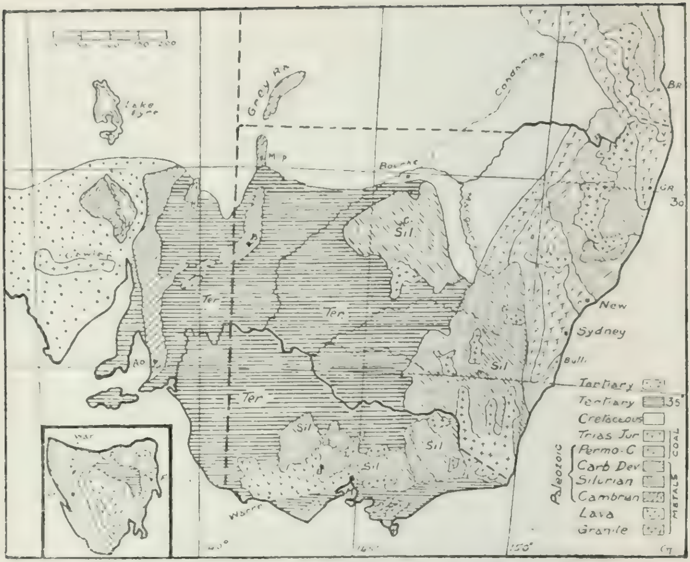

FIG. 29. The chief Geological Formations in South-East Australia.

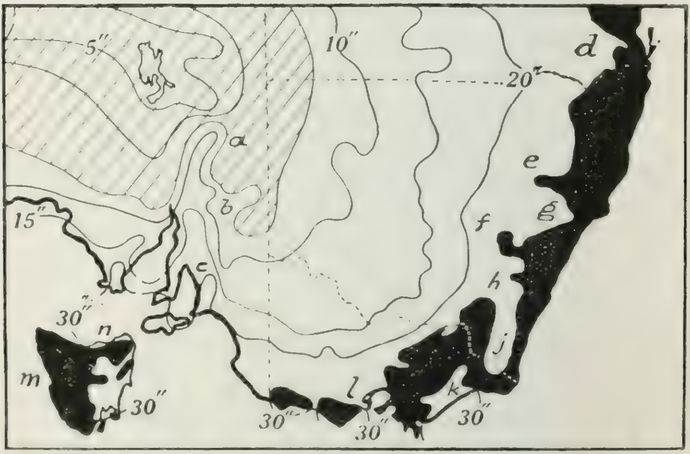

FIG. 30. Rainfall of South-East Australia.

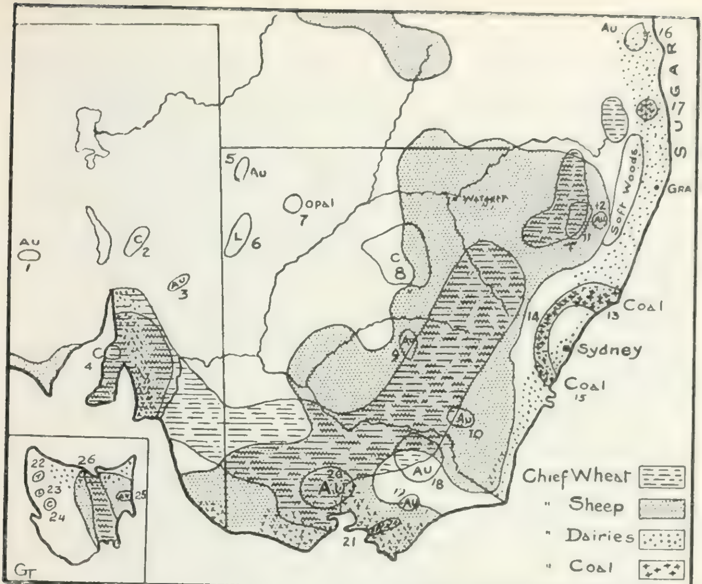

FIG. 31. Economic Map of South-East Australia. Au = gold; C = copper; T = tin; L = silver-lead. (Figures given in the text.)

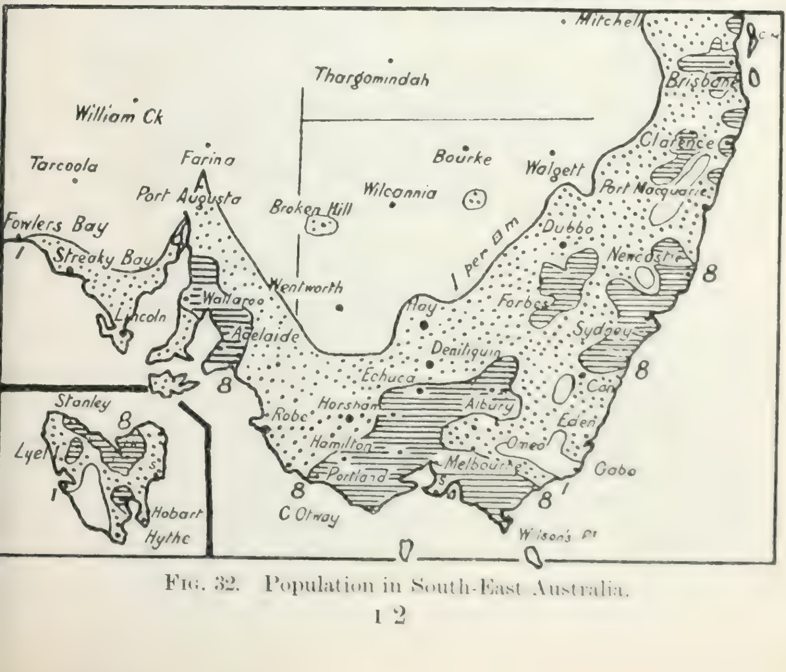

FIG. 32. Population in South-East Australia.

'blocks' of ancient sediments (buttressed by granite) in the east. The chief gaps at **Kilmore** and **Omeo** are probably largely due to the main rivers cutting away the rocks along old lines of weakness between the blocks. In the west the **volcanic flows** burst out near the top of the divide and have filled in the old valleys and smoothed all the topography around Ballarat.

The striking relation between the geology and topography of the **Flinders Range** in South Australia hardly needs emphasizing. The granite masses farther west have resisted erosion and stand out as the **Gawler Ranges** (see Fig. 29).

Undoubtedly the question of rainfall is of the first importance in a country devoted to agriculture and pastoral pursuits. In Fig. 30 the lines of equal rainfall (isohyets) are plotted giving the past fifteen years' average. It will be seen that the rain zones are parallel to the coast and to the belt of highlands. Such a distribution was to be expected.

The central lowlands (below sea-level at Lake Eyre) have **less than five inches** of rain per year. Thence the rain increases as the coast is approached. The loops and irregularities in the curves are purely **due to topography** and are worth close study.

The Flinders Range (rising to 3,900 feet) is responsible for the wet loop *a* (in Fig. 30). The slight elevation of ancient rocks on the Broken Hill line accounts for *b*. The Mount Lofty range gives rise to the wet loop *c*.

In Queensland the highlands are very narrow near Toowoomba, and so the 30-inch isohyet is near the coast at *d*. At *e* and *f* the volcanic masses of the Warrumbungles and Canobolas have much effect. At *g* the **Cassilis geocol** (as mentioned earlier) causes a dry loop to project to the sea. At *h* is the **Lake George gap** with a drop in the rainfall which is carried far south (to Cooma) in the lee of the Kosciusko Massif (as at j). The **rain shadow** near Sale is shown at k, while at l is the Geelong rain shadow.

The great effect of the western highlands of Tasmania is visible at m, and of Ben Lomond at n.

We may now consider the effect of these conditions on the commercial and industrial problems of the State.

Fig. 31 shows the distribution of different phases of development. Neglecting the mineral industry for the moment, the south-east region may be divided into three zones, each with its characteristic occupations. These may be called the Coastal Belt, the Highlands (see Figs. 20 and 21), and the Plains.

In the eastern portion of the south-east region the Highlands and coast receive 30 inches or over; in the western portion their rainfall diminishes to 20 inches or even less. The temperature falls off in the south also, hence the industries along the coast differ somewhat according to their latitude.

There is one distinct region in the north-east. Here truly **tropical products** are grown. Here **sugar** extends as far south as Grafton (Fig. 31), while **maize** flourishes largely along the same coast. The basalt slopes behind Grafton carry the valued cedar and other **soft-wood** timbers. These products also extend into the adjoining portion of Queensland.

Here also is the chief **dairy** region in New South Wales and Queensland. But this industry is not so closely confined by temperature. It extends all around the coast-lands wherever the rainfall is heavy enough to keep the pastures green most of the year. As we go south the coastal rainfall diminishes, but so does the evaporation. Hence many dairies are spread through Victoria (see Fig. 37A). In the Mount Gambier region, near Adelaide.

and in North Tasmania we have three centres from which the dairies will spread in the near future.

The Highlands are largely **cattle** and **sheep** regions. This is specially the case in New South Wales—where New England is extremely rich in sheep and the Southern Alps in cattle. The **Victorian Highlands** are too rugged and cold even for cattle to be very abundant, and the same conditions obtain in Tasmania. In South Australia the Mount Lofty Ranges and the coastlands here and also in Victoria are well suited for **sheep**—since the rainfall is much less than on the New South Wales coast. Sheep spread inland over the whole area shown in Fig. 31—but the chief centres lie on the western slopes in the eastern half of our map. In the drier regions (below 15 inches on Fig. 30) though sheep are less numerous, they are relatively more important since the **merino** is the chief interest of the whole population.

The **wheat belt** (on Fig. 31) also forms a zone around the central drier portion. Wetter conditions are more necessary in the north than in the south—partly through evaporation, but largely because the southern rainfall is more certain (see Fig. 17A). Near Geelong the wheat belt touches the coast, since here the coastal rainfall (19 inches) is lower than anywhere east of Adelaide.

With one exception we have dealt with the chief products which will bring about true *close settlement.* The **coal** deposits differ from other minerals in that they invariably lead to large populations. The region from Newcastle to Bulli is certain to become the most closely settled portion of Australia. **Sydney** itself stands in the centre of the coal basin, but the coal is here a mile underground (see Chapter XX). The capping of sterile sandstones has made Sydney poor in agricultural and pastoral resources, and this is shown clearly in the population map

(Fig. 32). Another less important but valuable coal belt occurs in Victoria to the south-east of Melbourne. Tasmania also has a potential manufacturing area near Fingal on the east coast.

The **metalliferous deposits** are of course entirely determined by the geological map. All the mines occur in the **older palaeozoic rocks,** as may be seen by comparing Figs. 29 and 31.

Thus in **South Australia** Blinman copper (2) and Teetulpa gold (3) occur in Cambrian rocks, while Moonta copper (4) and Tarcoola gold (1) are in small islands of ancient rock amid the Tertiary alluvial.

In **New South Wales** the same conditions are seen at Milparinka (gold 5) and Broken Hill (silver-lead-zinc 6). Cobar (copper 8), Wyalong (gold 9), Adelong (gold 10), and Hillgrove (gold 12) are mines in the more massive palaeozoic rocks of the Highlands. The Inverell granites contain tin (at 11).

Similar auriferous deposits are found in the ancient rocks of **Victoria.** The Beechworth group (18), Walhalla (19), and Ballarat (20) are of this class. In western **Tasmania** are the rich deposits—usually associated with granite—of Bischoff (tin 22), Zeehan (silver-lead 23), Lyell (copper 24), and Beaconsfield (gold 26).

Only one mineral occurs in the later *level-bedded* sediments. These have not been folded or faulted or penetrated by hot solutions of metals. But some solution of quartz has taken place in later geological time. This has been re-deposited as precious **opal.** Fields occur in the artesian basin near White Cliffs (7) and at Walgett.

The Distribution of Population in South-East Australia.

The last map of the series (Fig. 32) shows how the **population** has spread in accord with these economic and physical controls. By far the largest area of closely settled country (over 8 per square mile) is in **central Victoria.** Here the topography is favourable, the climate and rainfall are excellent, and wheat, dairying, and sheep are all flourishing.

Near **Sydney** is a smaller area (Fig. 32), since Sydney is handicapped by a rugged hinterland and sterile soils. But the great **coal belt** will more than make up for this. Just to the north is an area still almost unpopulated between the Capertee and Hunter Rivers.

The rich dairy regions of the **north coast** are well inhabited, and so are the **western slopes** of the New England and Blue Mountain Massifs. Isolated rugged areas occur behind Port Macquarie and near Canberra and Kosciusko which will never support much population.

The **drier coast** north of Mount Gambier (in S.A.) is marked by a sharp decline in population, which increases again around **Adelaide** for reasons which the preceding maps will have made clear.

In **Tasmania** the west is too rugged and wet for settlement. The **north coast** plains are the most favoured areas, but the Hobart region is also comparatively well settled.

In conclusion, it is obvious that the isohyets are the chief population controls. **In the south there is very little settlement below 10 inches, and in the north below 20 inches of rainfall per year.**

PART II

ECONOMIC ASPECTS

SECTION I. STOCKRAISING

CHAPTER XIV

THE WOOL INDUSTRY

THIS the staple industry of Australia[1] is confined within fairly well-defined limits. The controlling factors are almost wholly climatic and will be best understood by a reference to Fig. 33.

As a general statement it may be laid down that the sheep-breeding industry is most profitably carried on where there is between 20 and 30 inches of rainfall in the year. With a low rainfall the herbage is too scanty, though the indigenous 'saltbush' will grow where grass has no chance. On the other hand the saltbush is not readily renewed, and requires several seasons' rest when it has been severely cropped. Where the annual rainfall exceeds 30 inches the sheep need greater care, as they are liable to foot-rot and other diseases.

Temperature is another factor determining the distribution of sheep, which, as they possess a protective fleece, are essentially animals of the temperate zone. The northern limit of sheep-breeding appears to be usually defined by

[1] Both the Argentine Republic and the Russian Empire possess more sheep than Australia, the numbers in millions in 1915 being 80, 72, and 69.

an average temperature of 75° F.; though they thrive in the Kimberley region (W.A.) with temperatures much higher.

Fig. 33 is a generalized diagram showing the effect of combining the two factors of rainfall and temperature. It is at once apparent that almost the whole of New South

FIG. 33. Distribution of Sheep. Note that these are found mainly in areas with a rainfall between 10 and 30 inches (cf. Fig. 13).

Wales and Victoria lies in the sheep belt, while South Australia, Western Australia, and Queensland have chiefly their southern portions included in this suitable zone. The number of sheep and the percentage in each State of the Commonwealth and of New Zealand in 1908 and 1913 (in millions) were as follows:

	1908		1913	
New South Wales	43·3	49·8 %	39·7	46·8 %
Queensland	18·3	21·0 %	21·8	25·7 %
Victoria	12·6	14·5 %	12·1	14·2 %
South Australia	7·0	8·0 %	5·1	6·0 %
Western Australia	4·1	4·7 %	4·4	5·2 %
Tasmania	1·7	2·0 %	1·7	2·0 %
Northern Territory	—	—	0·07	0·1 %
	87·0	100	84·87	100
New Zealand (1909–11)	22·4		24·3	

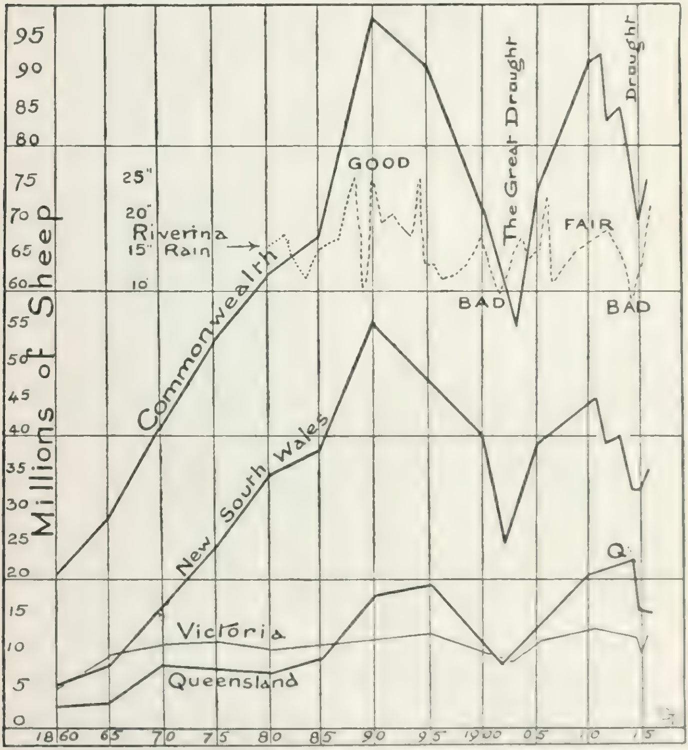

FIG. 34. Growth of Sheep Industry in Australia 1860–1916, showing effect of the droughts of 1902 and 1914. (The average rainfall for ten Riverina stations is shown by a dotted line.)

In Fig. 34 the variation in the number of sheep for each State for seven decades is charted. New South Wales has therefore, as many sheep as all the other Australian States added together, so it is legitimate and helpful to consider in some detail the wool industry of New South Wales as typical of the whole.

The sheep in New South Wales number some 40,000,000. This is a decrease of 20,000,000 from the number in 1891,

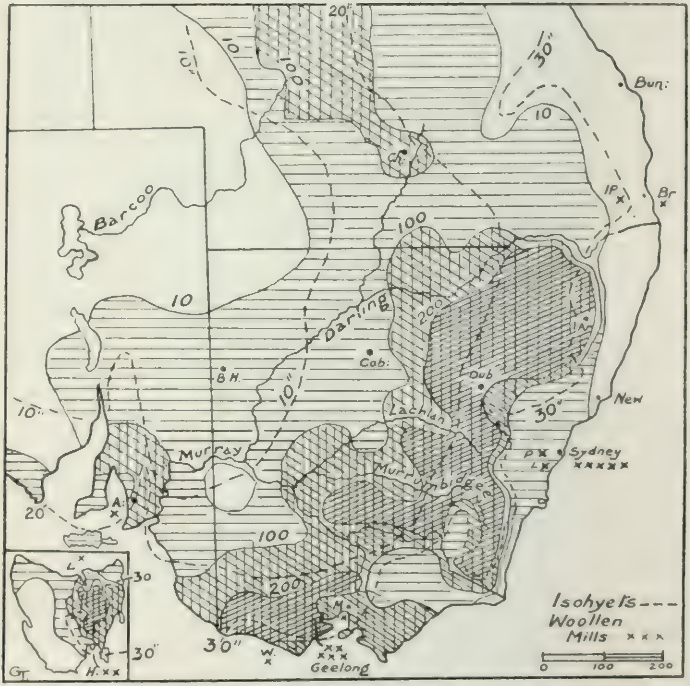

FIG. 35. Distribution of Sheep in South-East Australia. The greater number live between the 20-inch and 30-inch isohyets. Isopleths show 10, 100, and 200 sheep per square mile. (There are also mills at Castlemaine and Ballarat.)

when the runs were undoubtedly overstocked. The effect of a series of bad seasons on the pastoral industry is very strikingly shown by the drop (in Fig. 34) during 1901–2, when, it has been stated, the drought caused a loss of

£127,000,000 to Australia. Under present conditions New South Wales is comfortably stocked, but there is little doubt that with improvements in water conservation, and in the growth of food crops, the number of sheep will be enormously increased. At the average rate of increase since the Great Drought, the sheep would be doubled in four years.

The **distribution** of sheep in the State is shown by Fig. 35. Using the usual topographical divisions—the Coastal Belt, the Highlands, Western Slopes, and the Western Plains—the following table shows the quantity and quality of the sheep pastured thereon:

Belts.	*No. of sheep in 1904.*	*% of whole.*	*Breed of sheep.*	*Remarks.*
Coastal	1,037,011	3	Coarse wool sheep, such as Romney Marsh	Large hardy animals more suitable for mutton.
Highlands	7,783,680	23	Merino, coarse wool (Lincolns, Leicesters, &c.), with Merino cross breeds	A Lincoln carcass (dressed) weighs 60 lb. as opposed to 46 lb. for a Merino.
Western slope and Riverina	20,581,852	60	Best breeds of Merino	Best wool country in the World.
Western Plains	5,124,351	14	Somewhat poorer classes of Merino	Saltbush country, hot but healthy.

The greatest number of sheep are **fine-woolled Merinos**, which thrive better in New South Wales than anywhere else. The physique of the sheep, however, deteriorates unless vigorous **new stock** is introduced. This is largely obtained from Tasmania, which has a cooler and more bracing climate. Many **coarse-wool sheep**, and cross breeds between them and the Merino, are found in the coastal regions. The proportions are given as follows in the *Official Year Book*:

Fine wool	Merino	31,840,000
Coarse wool	Cross-bred, chiefly Lincoln-Merino . .	1,800,000
	Lincoln	250,000
	Leicester	170,000
	Romney Marsh, Shropshire, and South-Down	60,000
		34,120,000

In the rest of Australia the **distribution** is controlled by similar factors of rainfall and temperature, the former being the more important. The following table shows this:

	Rain control.		
	Optimum.	*Total.*	*Chief districts.*
New South Wales .	20 to 30 in.	10 to 40 in.	New England, Moree, Young, & Riverina.
Queensland . .	15 to 20	10 to 30	Longreach, Darling Downs, Cunnamulla, Clermont.
Victoria . . .	20 to 30	10 to 50	Hamilton, Ballarat.
S. Australia . .	20 to 30	5 to 30	Mt. Gambier, Adelaide.
W. Australia . .	20 to 30	8 to 40	Swanland, Carnarvon, Fitzroy River.
Tasmania . .	20 to 30	20 to 60	Longford, Oatlands.
N. Territory . .	—	10 to 20	Few. Barkly Tableland.

In **West Australia** the increase is very marked, and depends largely on railway or droving facilities. A very promising region for further development seems to lie along the south coast east of Albany.

In **South Australia** the numbers were greater in 1875. They range over the whole State except in the north-west, but relatively few extend beyond the 7-inch isohyet.

In **Queensland** sheep are paramount around Longreach, and the distribution maps show how the cattle and sheep alternate in Queensland.

In **Victoria** the most important area is a rectangle lying between Portland and Bendigo. The outer Mallee (in the north-west) and the mountain areas and rugged country in the south-east have very few sheep. Dairies are more profitable in the coastal regions.

In **Tasmania** the chief sheep districts lie between the two chief towns. The west is quite unoccupied and is too wet and bleak for sheep. The number has not altered for the last 50 years.

In recent years many changes have arisen in the sheep industry. Through careful breeding the fleeces have improved in quality almost beyond belief. The fleeces of the first flock were only about 3½ lb. in weight, while a modern prize **fleece weighs 30 or 40 lb.** The general average for the whole State has risen to 8 lb.

The conditions of ownership have altered materially. The large holdings ('stations') are being split up, although there is still one Riverina station with 150,000 sheep. Many of the small farmers practise **mixed farming**—rearing sheep, especially cross-bred, as well as raising agricultural crops. As this practice is proving very profitable it will doubtless be extended. The old method of shepherding sheep is gradually falling into disuse, and fencing-in large paddocks has proved more economical. The almost universal use of machine shears has lessened the labour of shearing.

One drawback of the pastoral industry has, however, changed for the worse of late years—the **rabbit plague.** Residents of other lands can have little conception of the damage done by these rodents. In the far west the rabbits eat all the grass off, and worse still, nibble the bark of the edible shrubs and saltbush (*Chenopodium, Atriplex,* &c.) The black and withered shrubs look as if a bush fire had swept over them. In these regions the writer has seen dead rabbits hanging in forked branches, into which they have slipped, having actually climbed small trees to get at the green leaves. The rabbits seem to be gradually marching east and north, and during the last ten years have spread over the divide towards Goulburn. The only means of defence, one which needs constant attention, is to put up rabbit-proof fencing, of which 44,000 miles, costing nearly £2,500,000, have been erected in New South Wales.

Shearing takes place chiefly during August and September, but is earlier in the north and later in colder portions of the State. The wool bales, each weighing about 350 lb., are sent in the greasy state to Sydney. Here a considerable portion of the wool is 'scoured', i.e. washed in soapy water. The 'yolk', a potash fat natural in wool, is thus removed and the wool rendered bright and clean. The valuable by-product is not utilized at present, but lubricating grease, and possibly potash-salts, will be extracted in the future, as they now are in France. The scoured wool is worth nearly double that of the greasy wool (25*d.*/15*d.* being the ratio). Most wool is now sold in Sydney in the greasy state. During 1905–6 only 11 per cent. of the Australasian wool was scoured.

As will appear from the following table, the greater proportion of Sydney wool (77 per cent. in 1906–7) was sold to buyers on the **continent of Europe**. This is a remarkable reversal of conditions, since not many years ago by far the larger part of the wool went to England, whence no doubt much was re-exported. It is, however, more convenient to send wool by the Suez route to Germany and France through Genoa and Marseilles than to carry it first to London. Continental buyers, who import unscoured wool, favour Sydney; Victoria and New Zealand send a much greater proportion of their wool to England.

DISTRIBUTION OF AUSTRALIAN WOOL, 1906–7 (IN BALES).

	Sydney Sales.	*Melbourne.*	*All Australia.*
Home Trade . . .	75,000	153,000	306,000
Continent . . .	513,000	190,000	783,000
Local manufacturers .	42,000	12,500	66,000
United States . . .	21,000	75,000	98,000
Japan and India . .	14,000	13,500	32,000

From Goldsbrough, Mort & Co.'s Report for 1906.

Although most of the sheep in Australia are bred for wool and are not profitably adapted for food, yet about

10 per cent. of them are used as **mutton**. Since the establishment of freezing works there is less risk of overstocking. Many breeders, especially in the Highlands, are breeding large cross-bred sheep for food supply.

In connexion with this most important industry in Australia, a short description of a big **shearing** may not be out of place. For further details on this and allied topics the reader is referred to Professor Cherry's book, *Victorian Agriculture* (Paterson, Melbourne, 1913).

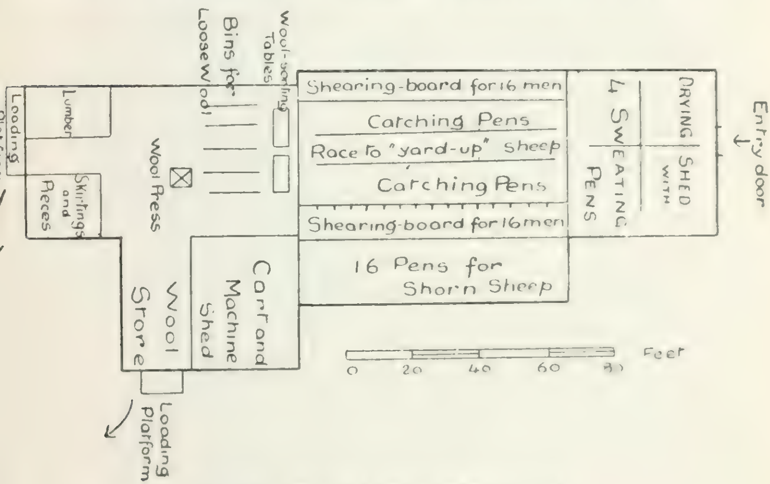

Fig. 36. Ground Plan of Wool-shed.

The work of shearing is done within a large building—the **wool-shed**—of which a typical ground-plan is given in Fig. 36. The sheep are driven into a drying shed which holds enough sheep for one day. It is important that the wool should be quite dry when shorn. Otherwise it ferments. (This fermentation is used in fellmongering to loosen the wool from the hides.) A portion of the sheep are from time to time driven into the 'yard up' and so into the small pens. Along the walls is the chief feature of the shed, the '**shearing-board**', where the men stand with their shears, machine or hand worked. After being shorn the sheep passes into the long narrow pen, where it can be inspected and turned loose.

The wool is carefully sorted and **packed in bales** of about 350 lb. each, either by a screw press or by hydraulic power. They are bound with hoop iron and carried to the ports for shipment to Europe or elsewhere. **Sailing vessels** go *via* Cape Horn owing to the prevalent winds. **Cargo steamers** usually travel *via* Capetown partly to avoid canal dues.

Woollen Mills. The opening of many woollen mills of late years in Australia marks a very important advance in the industry. There are about **two dozen** (1918), most of which are naturally at the industrial centres where the wool is collected rather than in the wool-growing areas.

Geelong has five mills, and **Sydney** has also five (mostly at Marrickville). Other mills (starting from the north) are Brisbane 1, Ipswich 1, Parramatta 1, Liverpool 1, Castlemaine 1, Melbourne 1, Ballarat 2, Warrnambool 1, Adelaide 1, Launceston, 1, and Hobart 2.[1]

[1] Data from *Pastoral Review*, Melbourne.

CHAPTER XV

CATTLE IN AUSTRALIA

This industry is not nearly so important as the sheep industry. Although in many of the cooler regions where sheep are reared, cattle also graze, yet the latter are found to thrive on **wetter country** than sheep. So as a rule the wetter districts in the **east and north** are the strongholds of cattle, which have been to a certain extent replaced by sheep in many of the more southern localities. In the annexed sketch-map (Fig. 37), showing the distribution of cattle in Australia, it will be seen that they are found most thickly along a belt which coincides fairly closely with the belt which has a mean annual **rainfall of over 20 inches,** while sheep thrive better in somewhat drier and more central districts.

A glance at Fig. 37 shows that Queensland is the chief cattle state. Here are the large areas of lands with more than 20 inches of rainfall, and it is in **Queensland** and **Northern Territory** that the chief cattle expansion will occur. We may expect to see the 'dense region' of Fig. 37 spread right across Australia to link up with the important district in Kimberley (W.A.).

In **Western Australia** the Fitzroy basin is the chief region. Nullagine is also important, in spite of its very high summer heat. The dairies are naturally confined to 'Swanland' in the south-west.

In **Northern Territory** the Victoria river country is much the most important. Barkly Tableland is second, and these two account for almost all the cattle. The

Roper and MacDonnells have about a dozen large stations. Most of the cattle in **South Australia** are near the coast in the dairy regions of Adelaide and Mount Gambier.

In **Queensland** the cattle are most abundant in the dairy regions in the south-east corner—and near the railway from Townsville towards Cloncurry. There are dairies, however, in the Herberton district so far north as latitude 17°.

The other States are described in later paragraphs.

The following table shows at a glance the relative importance of the States, the proportions reared for dairy purposes, and the areas of well-watered country:

State.	*Cattle* 1912.	*Per cent. of Australia.*	*Area over 20 inches. (sq. miles).*		*Dairy Cattle.*	*Per cent. of State.*
			Tropical.	*Temperate.*		
Queensland . .	5,210,891	45·0	313,183	80,000	375,660	7·2
New South Wales	3,033,726	26·2	—	130,468	852,040	28·0
Victoria . .	1,508,089	13·0	—	55,346	655,939	44·0
West Australia .	806,294	7·0	102,606	36,924	27,310	3·0
N. Territory .	405,552	3·5	180,940	—	300	0·07
S. Australia . .	383,418	3·3	—	14,875	114,734	33·6
Tasmania . .	222,181	2·0	—	25,278	60,160	27·0
Total . .	11,577,259	100·0	—	—	2,086,885	—

'On most Queensland **cattle stations** breeding and fattening are combined,[1] the heifers when weaned being drafted into a heifer paddock, to ensure their not breeding till of mature age; and the three-year-old steers being run in the bullock paddock, where they are kept till ripe for the butcher or the meat-preserving works. But on some stations where the creek flats and rich bottoms are of superior quality it is found more profitable to fatten only, store bullocks being bought annually during winter and spring, and turned off as "fats" as they mature during the summer. There are also a good many stock-owners who

[1] See *Queensland Year Book*, 1907, p. 79.

FIG. 37. Distribution of Cattle in Australia. Compare 20-inch isohyetal line, Fig. 13.

FIG. 37 A. Dairy Farming Regions in Victoria (based on Professor Cherry).

are fortunate enough to have freeholds of from 10 to 30,000 acres of rich land near a market, which they use for fattening, and which they supply with "stores" from their own breeding-stations leased to them by the Crown. Good fat bullocks on the coast country average from 760 to 800 lb. The cattle trucked from the west far exceed these weights, and the pens of **western bullocks** can be easily distinguished in the sale yards, great mountains of flesh scaling over 1,000 lb. when dressed, whose huge bulk, though somewhat wasted by travel, fairly dwarfs their coast-fed relatives. Such cattle have probably travelled hundreds of miles from their distant pastures to the railway trucks, but the quality of western grasses permits of cattle carrying condition for long distances without serious loss of weight.'

Two branches of cattle industry are receiving much attention in Australia at present. One is the frozen meat and meat-preserving trade, and the other **dairying.** A few words on the latter will not be out of place. The value of the export butter trade for the Commonwealth in 1913 was about £3,000,000. 'It is only during the last fourteen years that **Australian butter** has seriously influenced the London market, for though small consignments had been sent previously to London, the huge import into that city from Denmark and Sweden practically controlled the price of the Australian article. The position has, however, changed, for in 1905 Australian butter represented over 18 per cent. of the total imports, nearly one-third of all the butter imported into London during the winter months being of Australian origin.' [1]

The cattle bred for dairy purposes need milder climatic conditions than those reared for beef only, so that dairy-farming is mainly confined to the **coastal districts.** In New South Wales (see Fig. 38) the centre of the industry

[1] *The Official Year Book of New South Wales for 1905–6*, p. 409.

has migrated from the south coast to the north coast, where land is cheaper and the rainfall in general heavier than in the original centre of dairying in the Illawarra

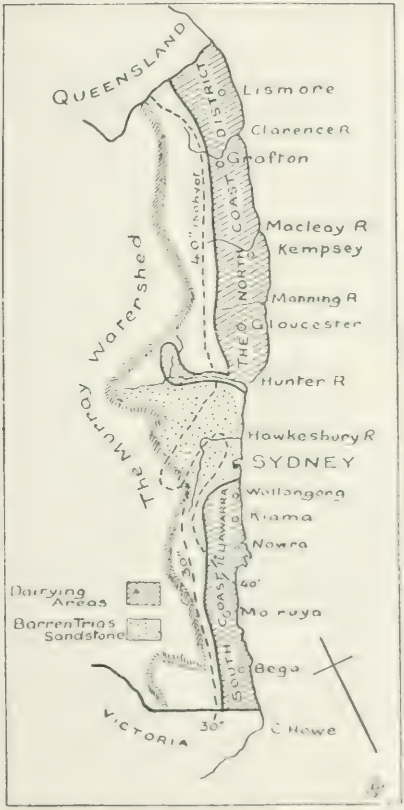

FIG. 38. Dairying Regions of New South Wales.

district. Mr. O'Callaghan (chief dairy expert in New South Wales) writes as follows :

'Along the coast it is quite safe to carry on dairying alone. Except in very extraordinary years the rainfall will be sufficient to make the success of the industry a certainty; but where a farmer moves inland to where the rainfall varies from say 27 to 30 inches per year, he has to think a bit more. In such districts the combination of dairying with wheat growing or mutton-raising, or both, might be entered into. . . . The breeding of cross-bred lambs for export goes very well with dairying, the sheep being confined to the higher lands and drier pastures, while the milch cows are allowed the run of the most succulent foods and grasses.'

Referring to Fig. 38, it will be seen that the two dairying districts are separated by a well-defined central area. This, as already pointed out, is the comparatively **barren district** where the coal measures have been capped by the triassic sandstones, which weather to a sandy soil lacking in plant food. It will be seen that the western boundary of the dairy country coincides very closely with the 40″ isohyet; and that the whole area is fairly well watered by short rivers rising in the highlands, which here approach within about 100 miles of the coast.

Seventy-five per cent. of milch cows in New South Wales are in the coastal districts, especially in the **Lismore district.** The distribution in the State in 1905–6 and in 1910 was as follows:

		1905–6	1910
Coastal (*vide* Fig. 38)	North Coast	117,811	237,065
	Hunter and Manning	80,762	125,475
	Triassic area round Sydney	21,475	22,951
	South Coast	103,300	94,690
Highlands	see Fig. 29.	62,460	71,733
Western slope		38,367	52,410
Western plains and Riverina		18,775	28,462
	Total	442,950	632,786

The following figures showing the breeds of cattle in New South Wales may be taken as typical of the whole continent (1905):

	Pure-bred.	Crossed with shorthorn.
Shorthorn (Durham)	571,337	
Hereford	171,252	295,000
Devon	63,688	160,000
Ayrshire	34,645	91,000
Jersey	24,913	24,000
Totals	865,835	570,000

Other breeds recognizable	100,000 approx.
Unrecognizable	502,962
In towns (unclassified)	297,273
Total	2,300,000 approx.

The dairy farms in **Victoria** are distributed over four fairly well-defined districts (see Fig. 37 A). In the map (based on one by Professor Cherry) two areas in the State are of little importance, the north-west because it is too dry, and the central-east because it is too rugged. An interesting tongue with an annual rainfall of less than 25 inches extends from the Wimmera to Geelong—and here also dairying is not very extensively carried on. The most flourishing regions are those surrounding **Terang** in the Western area, and **Western Gippsland**. The Northern area is not progressing as rapidly as might be expected. Northward nearer the Murray the dairy farmers depend on water supplied by the **irrigation channels** (see p. 173).

In the far north of the continent, from Melville Island to the Gulf Country, is the habitat of the **wild buffalo**. This animal was introduced from the Malay Archipelago, when Government settlements were founded in the northern territories in 1827. When the settlements were abandoned the cattle ran wild and now number many thousands. Melville Island is the stronghold of a powerful tribe of Australian aborigines, who allow no white men on their island, with the exception of a small party of buffalo hunters. This animal must not be confused with the bison (the so-called 'buffalo'), which has been practically exterminated in North America. It is characterized by the fact that the horns are flattened and angulated, not rounded, as in oxen and bison, and are placed below the vertex of the skull. Some Australian bulls are stated to have reached a ton weight, and their hides, 'reaching nearly an inch in thickness', are yielding satisfactory incomes to hunters in the far North.

It is possible that the **Indian zebu** will resist disease and insect pests in the wet coastlands. Healthy hybrids with shorthorns have been raised in West Australia.

CHAPTER XVI

ARTESIAN WATER[1]

This subject may well be considered in conjunction with that of the pastoral industry. Whatever may be the opinion as to the value of artesian water in agriculture, there is absolutely none as to the vital assistance it offers the harassed stock-owner in times of drought, and equally none as to its merits in **keeping open the great stock routes.**

Much of Central Australia probably cannot be reclaimed. The soil is rich in plant foods, but without moisture these possess no value. A very occasional moderately wet year works a wonderful change and has led to temporary settlement. The saltbush formerly formed an excellent food for sheep, but, as mentioned in Chapter XIV, p. 143, the rabbit plague has devastated the country, so that forlorn, broken-down fences alone testify that the country was once occupied. Till one gets to the far northern portion, mining is practically the only industry attracting any attention.

Practically the only mitigating influence in this arid region is the presence of artesian water in the east.

In Fig. 39 the very large extent of the **chief Australian artesian basin** is apparent. It indeed includes 570,000 square miles, comprising more than half of Queensland

[1] There are other artesian basins not described here as they are not yet very important. (1) Eucla Basin (brackish) about 200 miles radius from that centre. (2) Desert Basin extending 400 miles east from Broome, W.A. (3) N.W. Basin around Shark Bay. (4) The small but important Basin along the coast north of Perth. (5) The Murray Basin shown as the 'Tertiary Sea' in Fig. 24.

and important slices of New South Wales and South Australia.

The various governments concerned have spent large sums in sinking bores, usually by diamond drill. In

Fig. 39. Artesian Basins of Australia.

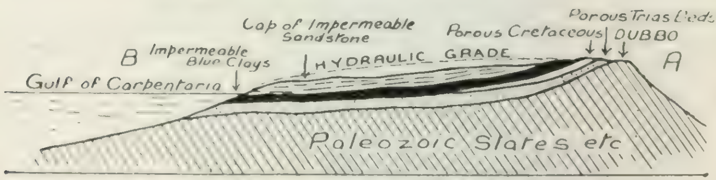

Fig. 39 a. Artesian Water in Australia.

New South Wales there are nearly 200 Government bores giving 63,000,000 gallons per day, or approximately 330,000 each. At Dolgelly, in the south-east of the basin, a bore was sunk 4,086 feet and gave 682,000 gallons per day. At Kenmare in New South Wales (see Fig. 39) over 2,000,000 gallons are obtained. There are also about 250 private bores, with a total flow of 150,000,000 gallons per day.

In **Queensland** over 400 *miles* of boring have been put down. There are nearly 800 flowing bores and 330 sub-artesian, where the water does not flow to the surface, but is pumped up. The deepest bore is 5,045 feet at Bimerah near the upper Barcoo. At Millungera in the Gulf country the bore gives about 5,000,000 gallons daily.

In **South Australia** (Fig. 39) the artesian basin is far distant from settled areas. The railway at Oodnadatta reaches the artesian basin near Hergott Springs. Here the great Queensland **stock route** commences, and during the period August to December, 1901, 14,000 cattle and nearly as many sheep passed along this route. This has been made possible by means of the Government bores and tanks. There are five bores connecting Hergott with Cooper's Creek (Barcoo R.) at Kopperamanna, and nearly 100 bores in the State.[1]

In the Mallee district of **Victoria** 42 bores are in use, though the water rarely rises to the surface.

The cost of boring varies with the location and rock. For each foot down to 2,000 feet, charges range from fourteen to forty-two shillings. At 4,000 feet the range is from twenty-eight to sixty-five shillings. The scales for watering stock are usually one shilling per hundred for sheep, and one penny each for horses, cattle, and camels.

Enough has been said to demonstrate the value of artesian bores to travelling stock. As regards their **use in agriculture** opinions differ. It has been stated that

[1] A vivid description of this portion of Australia Infelix is given in Gregory's *Dead Heart of Australia*. Here also he discusses the origin of the artesian water, advancing the plutonic theory, which is briefly mentioned at the end of this chapter.

artesian water rapidly saturates agricultural land with salts, chiefly sodium carbonate. The following analysis (by Mr. J. C. Mingaye) shows the total grains of solid matter in a gallon of Pera water (a bore near Bourke, New South Wales):

Sodium Carbonate . . .	33·12
Potassium Carbonate . . .	1·20
Sodium Chloride	7·69
Silica	1·06
Lime Carbonate	0·85
Traces of other salts . . .	1·12
Total solids . .	45·04 grains

Experiments with this water have yielded very good results in the case of fruits, lucerne, &c., and the above analysis would seem to be an average type of the artesian supply. There can be little doubt, however, that conservation of *surface* water for irrigation purposes is capable of yielding profits on a much greater scale. Probably in the future most attention will be given to this method of making the desert bloom, in the few regions where it is possible.

The present arid conditions in Central Australia and the structure of the artesian basin can be most clearly explained by a brief review of the **geological history** of this area.

Around the shallow salt lakes of South Australia (Fig. 26) is a happy hunting-ground for geologists. Here occur skeletons of **extinct animals** of comparatively recent date, such as the giant emu, giant kangaroo, alligator, tortoise, and giant wombat. The latter (*Diprotodon*), some 16 feet long, was a herbivorous animal, flourishing only in well-grassed and fairly well-watered country. All of these have become extinct, and only where they have been engulfed in mud are their bones preserved to tell of a time when Central Australia was a smiling, fertile region.

The central portion of Australia has been subjected to many ups and downs during the tertiary period (see p. 218). About the time when huge reptiles dominated the animal kingdom (jurassic and cretaceous periods, see footnote, p. 28), **a large gulf** undoubtedly extended from the Gulf of Carpentaria to Lake Eyre (see Fig. 40). This covered much the same ground as the artesian basin, and in it were deposited thick beds of sand which ultimately became a permeable sandstone. Over these were laid down clays

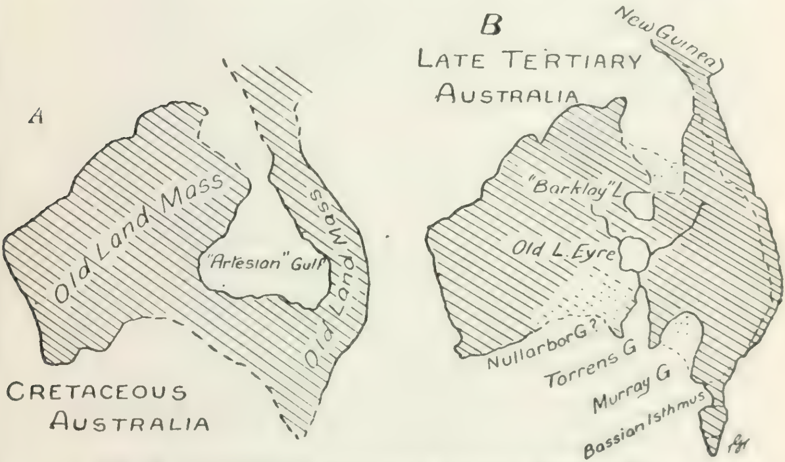

FIG. 40. Australia in Cretaceous and Late Tertiary Times.

of an **impermeable nature** (blue clays, &c.) and other strata of less interest.

Later, earth movements **elevated this area**, and the action of wind and weather eroded the eastern edge of the basin, exposing the underlying porous sandstone (see section *B–A*, Fig. 39 A).

The more **recent history of the artesian basin** is of great interest and shows how the climate gradually became more and more arid, until its present condition was attained.

Professor Gregory is of the opinion (see *The Dead Heart of Australia*) that *after* the deposition of the cretaceous sediments in the artesian gulf and their elevation into land, a series of earthquakes, resulting in parallel fractures or faults, led to the formation of the South Australian gulfs, and probably of Lake Torrens (see Fig. 26), so that there may never have been a continuous gulf across Australia from north to south. There was then a **much greater rainfall** in Central Australia, probably due to the larger water surface. Lake Eyre had an outlet and formed a magnificent sheet of fresh water which extended over three times the present area, and was fed by large rivers. At this period flourished the gigantic animals mentioned previously. Unfortunately this happy environment has not lasted. It seems probable that this lowland zone from gulf to gulf (see Fig. 40, *B*) has been subjected to a **movement of elevation,** leading to land extensions, giving Australia its more familiar outline, and causing the drying of Lake Eyre, and the exposure of the tertiary deposits of the Barkly Tableland and elsewhere. At the same time, there was a movement of **subsidence along the eastern coast,** accompanied by earthquake slips in Bass Straits, and possibly in Torres Straits, leading to the separation of Tasmania and New Guinea. Along the rest of the coast a more gradual subsidence led to the formation of splendid harbours from drowned river valleys (e. g. Sydney), and indirectly to the formation of the Great Barrier Reef[1] (see pp. 216–17).

The rain falling on the **upturned porous beds** (which are chiefly trias in New South Wales and cretaceous in North Queensland) is rapidly absorbed and flows under-

[1] The aspect of environment dealing with this 'rocking' of coast and lowland is developed in a paper read before the Australian Association for the Advancement of Science, Adelaide (Hedley and Taylor, *The Reefs of the Great Barrier*, 1907).

ground towards the lower portion of the basin, which probably occurs in the north. In fact, it seems likely that there is a large leakage from the north of the basin into the Gulf of Carpentaria. Probably the mound springs near Lake Eyre form other outlets. How does the artesian water rise in the bores to a height considerably above sea-level in the gulf? Professor David has shown[1] that the frictional resistance to continued flow, which must be very great, is equivalent to a barrier in the sense that it induces a hydraulic pressure. Hence the height to which the water rises above ground gradually diminishes as the outlet of the basin is approached (see line of hydraulic grade in the section, Fig. 39 A).

In conclusion, it may be stated that the theory of the *atmospheric* origin of the artesian water has been questioned by Professor Gregory. He suggests that it is mainly derived from water which is included in minute cavities in almost all granites and other similar rocks. He instances the steam escaping from volcanoes and the presence of ores, deposited by thermal water, as evidence of large quantities of underground water. The diminution of some bores, pointing to their possible exhaustion, and the chemical contents of the waters lend considerable support to the *plutonic* or underground origin theory of artesian water. The balance of opinion is,[2] however, in favour of the artesian water being directly derived from rain falling on to porous outcrops, and thence supplying the water-bearing strata many hundred feet below the arid surface.

[1] For a lucid account of the artesian basin, see Pittman's *Mineral Resources of New South Wales*, p. 457.

[2] Strong arguments against Professor Gregory's theory of the plutonic origin of artesian water were set forth by Mr. Pittman before the Royal Society of New South Wales, October 31, 1907.

SECTION II. AGRICULTURE

CHAPTER XVII

WHEAT IN AUSTRALIA

Most Australian wheat is grown in Victoria, New South Wales, and South Australia. For 1912–13 the figures were:

	Acres.	Bushels.
Victoria	2,085,216	26,223,104
New South Wales . . .	2,230,500	32,466,506
South Australia	2,079,683	21,496,216
Western Australia . . .	793,096	9,168,594
Queensland	124,963	1,975,505
Tasmania	25,226	630,305

The map of the wheat areas shows how intimately they are related to the rain belts (see Figs. 41, 41 A, and 13).

New South Wales. The western limit of profitable wheat-growing in New South Wales practically coincides with the mean *annual* rainfall of 20 inches.[1] A little more rain is needed in the *hotter* northern portion, while in the south, on the Murray, a little less suffices. A great deal depends on the month in which the scattered Australian rainfall occurs. September and October, the period during which the grain fills, are the most critical months.

In 1897 there was first a surplus for export in New South Wales. The value of the crop in 1903 was £4,000,000, in 1912 £5,000,000, and in the excellent year 1915

[1] Mr. H. A. Hunt reports the following areas as receiving over 10 inches in the wheat period (April–October): West Australia, 93,500 sq. m.; South Australia, 46.980; Queensland, 79,247; New South Wales, 163,772; Victoria, 74,616; and Tasmania, 26,215. Perhaps half is unsuitable for various reasons, but a total wheat area of 500,000 sq. m. may be reached with the help of dry farming.

£15,000,000. The total crop in the Commonwealth in the year 1915–16 was worth over £40,000,000.

A glance at the map (Fig. 41) shows that the region of greatest production is in the **Riverina,** and extends thence north-east (to Dubbo) on the **western slopes.** In fact, the control is purely that of rainfall, for we see

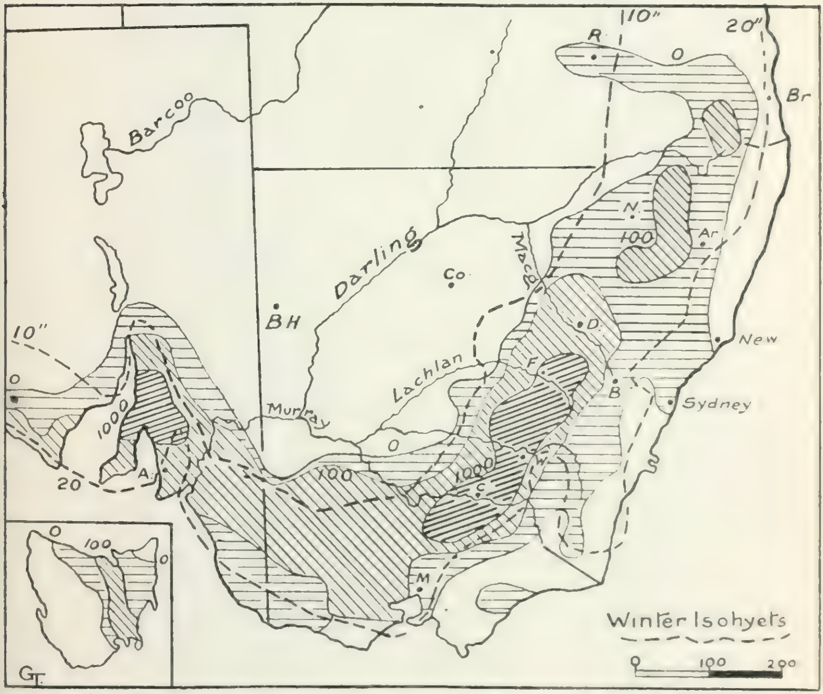

Fig. 41. Wheat areas in South-east Australia.[7] The figures 0, 100, and 1000 are bushels per square mile. The wheat belt is limited by the 10-inch and 20-inch winter isohyets (i.e. rainfall April–October).

that the western boundary almost agrees with Mr. Hunt's **ten-inch winter-rainfall** line.

The low rainfall in the Cassilis Gate is probably responsible for the break in the belt hereabouts. The outer limit is slowly moving westward, but will not vary much for many years to come. It will be seen that a little more rain is needed in the north than in the south to counteract evaporation and rain-variability. There is very little wheat grown in the **wet coastal** districts.

WHEAT YIELD 1915 16.

Division.	*Crops in Bushels.*	*Average per County in Division.*
Coastal	108,111	6,000 bushels
Tablelands	1,648,425	69,000 ,,
N.W. Slope	5,788,460	640,000 ,,
Central W. Slope	11,975,140	2,000,000 ,,
South W. Slope	17,588,525	2,200,000 ,,
Western Plains	6,029,350	350,000 ,,
Riverina	24,177,095	1,700,000 ,,
Darling Basin	8,285	—

The above table (based on the Statistical Register) shows that the **south-west slope** (Wagga, Temora, Wyalong, Young, and Cootamundra), the **central west slope** (Dubbo, Parkes, Grenfell, Molong, Cowra), and **Riverina** (Albury, Deniliquin, Marandera) are the chief districts. Gunnedah and Tamworth in the north are two other very important regions.

In some of the northern districts within the line much of the land is considered unsuitable for wheat-growing, consisting of stony, hilly country, unfit for cultivation, and of black soil plains which bake and crack and present mechanical difficulties in tillage. The rich soils of river flats must also be omitted from good wheat-growing areas, as such land has a tendency to produce excessive growth of straw, which, however, makes excellent hay. Excluding the coastal tract, where wheat-growing has been practically abandoned during recent years owing to liability to rust, the area comprised within the wheat belt and suitable for its cultivation has been estimated to cover from 20,000,000 to 25,000,000 acres. The area actually under wheat is about 2,200,000 acres, which is only one-tenth or one-twelfth of the total mentioned.

Compared with the principal wheat-growing countries of the world the average yield of 11·3 bushels per acre is very small, since the United Kingdom has an average of 32, Germany 30, and Canada 25. But during 1912 Australian wheat had a higher value than that from any other country, being quoted at 38*s.* 5*d.* per quarter, or 3*s.* 8*d.* higher than English wheat. During 1913 the Commonwealth exported over 42,000,000 bushels, of which 28,000,000 went to the United Kingdom.

The greatest area under cultivation in **Victoria** lies in the north and north-west, in the Wimmera, Mallee, and Northern districts. The eleven north-west counties—Lowan, Borung, Kara Kara (Wimmera); Weeah, Karkarook, Tatchera (Mallee); and Gunbower, Gladstone, Bendigo, Rodney, and Moira (Northern)—contain 93 per cent. of the area under wheat in Victoria. The irrigation counties of Rodney and Moira are seen to be the most important (Fig. 41). In 1912 over 2,000,000 acres were devoted to wheat, giving an average of 12·5 bushels per acre for the State. The average yield per acre for the chief wheat *counties* is shown on the map. There has been a falling off in the Wimmera and Mallee districts of late, where the tendency is for growers to combine sheep farming with cultivation.

Recent investigations in the Mallee country have shown that many acres suitable for wheat cultivation are awaiting exploitation; while over the border, in South Australia, the rainfall is sufficient around Pinnaroo to justify the settlement which is going ahead very rapidly along the numerous new railways.

In **South Australia** there is a northward bulge in the isohyets, caused by the Flinders Range and possibly influenced also by the long gulfs running 200 miles into the continent. Here six counties around St. Vincent Gulf each produced more than 2,000,000 bushels for the season 1915–16. These were Daly, Gawler, Stanley, and Victoria (which are entered at Wallaroo and Port Pirie); Frome (between Port Pirie and Port Augusta); and sixth Fergusson, comprising Yorke Peninsula (with Edithburg for the chief port). Much wheat is also grown across Spencer Gulf, on the coasts of Eyre's Peninsula, where the chief town is Port Lincoln.

The wheat crop in 1915–16 was worth £8,500,000. The following table gives the proportions shipped from the chief ports during 1913–14:

	Bushels 1913–14
Port Adelaide	4,216,114
Port Wallaroo	2,457,060
Port Pirie	2,406,227
Port Victoria	577,086
Port Lincoln	346,714

In South Australia three-quarters of the rain falls in winter, the summer is warm and dry and periods of several months without rain are frequent. These conditions are very suitable for harvesting the wheat crop. Cereals are sown in April and May and make most of their growth before summer sets in. The warm weather of early summer (October–November) brings the crop to maturity, usually resulting in the production of a bright heavy grain, highly appreciated in the world's markets on account of its dryness and the colour and quality of its flour. The nature of the summer, except in the cooler districts, militates against the cultivation of summer crops on an extensive scale except with the aid of irrigation, and consequently the skill and energy of the farmer have been mainly directed to the growing of winter cereals and the breeding of stock.

The following rainfall record for 1907 for one of the typical wheat growing districts in South Australia will give the reader an idea of the distribution of rain in its relation to the cereal crop:

	Inches.		
January	0·00	(see p. 50 on *seasonal* rainfall)	
February	0·93		
March	0·29		
April	3·07	(Sowing)	
May	1·06	(Sowing)	Total rainfall during period of growth of crop, 12·08 inches.
June	1·36		
July	2·88		
August	2·79		
September	0·70		
October	1·33		
November	1·98	(Harvest)	
December	0·67		
	17·06		

Under conditions such as these crops of 30 bushels to 40 bushels per acre have been reaped by many farmers during the past few years from land worked according to scientific principles. A new-comer from the Old Country landing in South Australia, say in January, after a period of dry summer weather, would probably find the parched appearance of the fields uninviting and would form a poor idea of the capabilities of the country were he not acquainted with our records. As far back as 1838 Captain Sturt publicly warned the settlers that to attempt to cultivate the land on the Adelaide plains would result in disaster. This same land now is probably worth for cultivation purposes an average of £15 per acre, while a very large proportion of it realizes £40 and more per acre for the growing of green crops, fruits, and vegetables.

Of late years there has been a slight falling off in the quantity of land under wheat. This may be attributed to two causes. Firstly, twenty-five years ago a large area of northern country was broken up by the wheat-grower, but experience having shown that much of this land was better adapted for grazing, a large proportion of it is now utilized for dairying and for sheep. Secondly, the farmer has recognized that it is more profitable to sow smaller areas of well-tilled land than a large acreage insufficiently prepared. In 1906 the percentage of fallow was 51·7.

The aim of the farmer in the comparatively dry areas is, as far as possible, to utilize the rainfall of two winters for one season's crop, by a three years' rotation, viz. grazing, bare fallow, cereals. After the cereal crop is harvested, stock graze on the stubble and the pastures during the ensuing eighteen months. The land is then ploughed up early in the winter to permit of the rains penetrating deeply and to avoid loss of moisture by running off. This having been done, the surface of the land is kept loose and fine during the following spring and summer, to retard the evaporation of soil moisture. The following winter the land so treated is sown with cereals.[1]

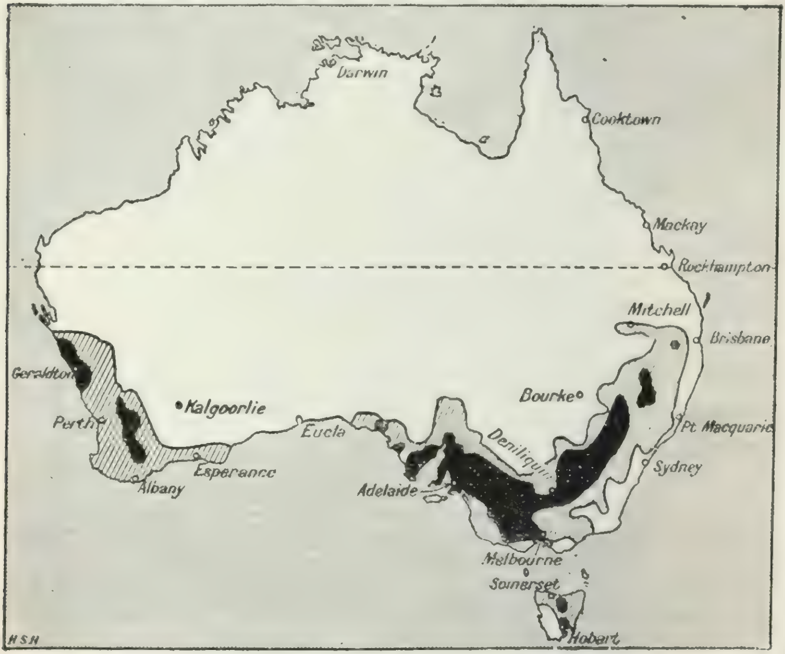

FIG. 41 A. Wheat about 1912.

In West Australia the wheat belt is also controlled by the 10-inch winter isohyet. The best yields are around York, but great progress is being made towards the south-east, where half a dozen new branch railways are opening up the wheat belt.

[1] The above account is from a Government publication, *Notes on Agriculture in South Australia*, 1908, which should be consulted.

As in the United States, it will be noticed that the wheat limit is gradually moving west. The cautious statements of the Government report indicate that this cannot be pushed much farther. The Burrinjuck irrigation scheme will extend the area in the Riverina. Other large areas are round Pinnaroo[1] and Eyre's Peninsula in South Australia, while Western Australia has immense timber areas which will grow excellent wheat when cleared. The chief increase will be due to a more thorough cultivation of existing wheat areas. A comparison with India as a wheat country shows that there the chief area lies between the 10 and 40-inch isohyets, and the 55° and 65° F. winter isotherms. In Australia, we find that these enclose an area which includes the Upper Darling and its tributaries, and extends almost to the tropic of Capricorn. So that irrigation may convert this into a granary such as obtains in India, though at present little wheat is grown in Queensland.

[1] Mr. A. S. Kenyon writes of this region: 'Fallowing has rendered possible the profitable cultivation of wheat in country with less than ten inches of rainfall, particularly if an undue proportion falls in the winter months. The secret, however, does not lie in the rainfall, but in the extremely light nature of the soil, which renders the draught of the implements exceedingly low. Wheat can be produced on sandy mallee land at 1*s.* 3*d.* a bushel.'

CHAPTER XVIII

SURFACE WATER IRRIGATION AND SUPPLY

THE future of the larger portion of Australia is controlled by the question of water supply. Reverting to the rainfall map of Australia (Fig. 13), it will be seen that 36 per cent. (perhaps more) of the continent is included within the 10-inch isohyet. Little can ever be done to reclaim this vast arid region,[1] but around its borders, especially **near the few large rivers,** very considerable areas have been and will be rescued from the sterile and useless moiety of the continent. We have seen that a large area in the north-east lies within the Artesian Basin, and here, therefore, nature has supplied water underground. In this chapter, however, we shall deal with supplies obtained from rivers or carried from natural bodies of water in sluices or pipes.

The **chief irrigated areas** are naturally situated where the more populous regions abut on the arid central region, i.e. in the south-west and south-east of the continent. In the Murray Basin, in New South Wales and Victoria, is gradually arising a comprehensive scheme of water supply extending from Bathurst to Ballarat. In Western Australia there is a water scheme developed to cope with the unusual arid environment of that State's chief industrial centre—the Coolgardie Gold-field.

[1] About 9 parts in 10,000 of the land requiring irrigation are at present so watered !

Irrigation in the Murray Basin.

This portion of Australia contains almost one-fifth of the continent, and, with the narrow strip between the basin and the sea, supports three-quarters of the population of Australia. Yet this huge area has only 1 per cent. of the

FIG. 42. The Murray-Darling Basin (after R. McKay) showing the *effective* Catchment Area (shaded). The greatest and least annual flow (in thousand million gallons) at the important river towns is indicated also.

population of Japan, an empire which is not much bigger than Victoria and but half the extent of New South Wales. It therefore behoves Australians to make the best use of this land, the greater part of which, although its rainfall is much less than that of Japan, is of economic value, and has a soil in many districts unrivalled for fertility and depth. In a valuable monograph by Robert T. McKay on the Murray River[1] it is stated that its basin occupies 414,253 square miles, while the effective catchment area comprises only 158,499 miles or about 38 per cent. As Mr. McKay states, however, the main factor militating for ever against a close settlement is that the quantity of water needed for irrigation is so great, that the land which requires irrigation for fertility will always be in excess of the capabilities of the water available for irrigation.

In Fig. 42 the amount of available water (in thousand million cubic feet) is indicated for the highest and lowest years. With such variations, conservation is absolutely necessary, otherwise ordinary supply canals for irrigation will be empty in time of drought when the supply is most needed. Thus on the Lachlan in *one month* (July) during 1900 more than 19,000,000,000 cubic feet passed the gauging station at Forbes. Yet in the *whole* of 1902 only a little more than 5 per cent. of this volume (1,000,000,000) flowed down the river, which indeed was a mere string of water-holes during the greater part of that year. Contrast also the results at Wilcannia (on the Darling) for 1890 (717,000,000,000) and 1902, when the river ceased for eleven months (709,000,000). Similar figures are given for the other chief river towns.

There are no tributaries joining the Murray in South Australia, and it has been computed that of the total in the main stream New South Wales contributes 293,000,000,000 and Victoria only 153,000,000,000, or approximately half the supply of the Mother State, though Victoria has so far been much more progressive in the matter of irrigation.

[1] A lecture delivered before the Sydney University Engineering Society on August 19, 1903. This lengthy and exhaustive paper is illustrated by numerous photographs and maps, and as the reprint is not widely circulated the present writer has ventured to make considerable use of it.

Unfortunately the whole of the drier portions of the basin (with rainfall less than 20 inches) cannot be irrigated. Obviously only comparatively low-lying land can be watered in this manner, and only suitable soils are worth the expense. Fortunately the Murray tributaries in their lower courses flow over a vast alluvial plain, partly estuarine and partly fluviatile in origin. A large estuary in late geological time extended as far as Balranald and Menindie (shown in Fig. 42 as the tertiary shore), and this received river silts and mud brought down by the ancestors of the modern Murray tributaries. The whole has been elevated in the late tertiary times, resulting in the 'Mallee' country around the confluence of the Darling and Murray.

The topographical features have made it easier for Victoria than for New South Wales to utilize the waters of its rivers. The catchment area is nearer to the irrigable flats and in general at a higher elevation, leading to less costly pipe-lines and channels.

Irrigation in Victoria.

The chief areas which have benefited by irrigation (with one exception) are all situated in the **northern lowlands** of Victoria. Here the Victorians have spent £7,750,000 in remunerative works, chiefly on reservoirs and their attendant channels. Some 276,000 acres, about one-tenth of the area controlled by the various irrigation trusts, are irrigated.

The four chief river systems affected are the **Wimmera, Loddon, Campaspe,** and **Goulburn** (see Fig. 43). On the latter river a large weir has been constructed 8 miles above *Murchison*. It raises the water level 45 feet and supplies 600 farms in the Rodney district, with the result that during the great drought of 1902 the farmers were fattening stock and supplying fodder to the starving Riverina just across the Murray.

At *Laanecoorie* (close to Poseidon, famous for the gold rush of 1906–7) a weir sends the water up the Loddon River for $5\frac{1}{2}$ miles. It maintains the supply of the Boort

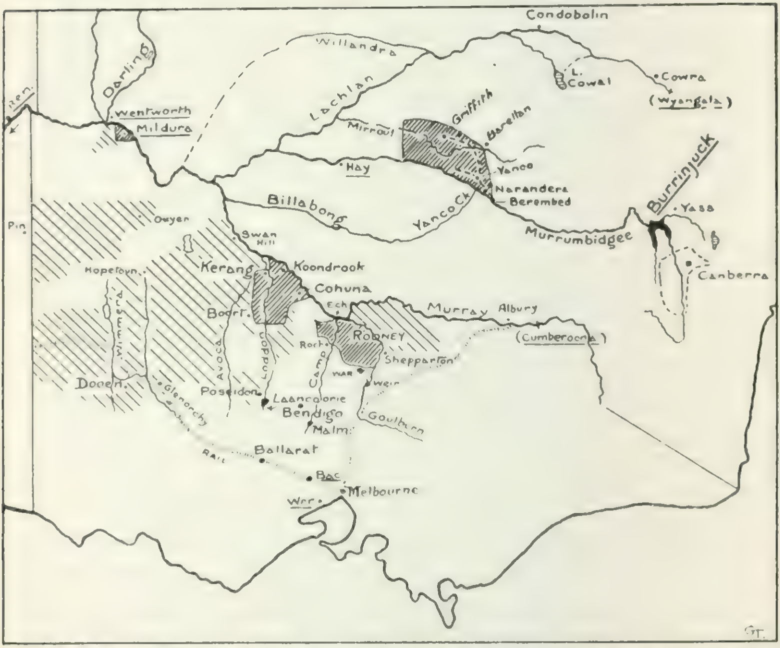

FIG. 43. Irrigation and Water Supply in New South Wales and Victoria. The open-ruling shows waterworks districts. Small irrigation settlements are underlined.

irrigations and Bullock Creek Water Trust.[1] At *Malmesbury* on the Upper Campaspe is a group of works which supply water to the great mining centre at Bendigo. It is stated that the latter town has a cheaper supply for its

[1] A Water Trust is formed to supply water for stock and domestic purposes, where the supply is not sufficient for extensive irrigation. Mr. Kenyon has kindly supplied some Victorian details.

mines than almost any other, and is thus enabled to profitably treat low-grade ores.

Near **Kerang** on the Murray, below Echuca, are works costing £200,000. They carry Murray water into a reservoir, whence it can be diverted to irrigation areas in Gunbower. In dry weather the lower Loddon can be supplied from this reservoir.

On the upper Wimmera are two smaller schemes. *Glenorchy* supplies the Wimmera Trust by means of Richardson Creek; and *Dooen* Pumping Station is connected with a canal network of 155 miles to the north in the Western Wimmera, which is, however, chiefly used to water stock.

The larger portion of the area defined on the map is held by the Water Trusts, and the main areas under Irrigation Trusts are at Boort-Gunbower (Kerang) and Rodney (Goulburn).

Chief Victorian Irrigated Areas, 1912–13.

Tragowel (near Kerang)	38,000 acres.
Rodney (near Goulburn R.)	38,000 ,,
Cohuna (near Kerang)	26,000 ,,
Koondrook (on Murray, do.)	14,000 ,,
Rochester (on Lower Campaspe)	7,000 ,,

The great fertility of the soil when supplied with water is shown by the results at **Mildura** on the Murray River, near the South Australian border. Of the former town it has been stated that an area of 8,000 acres is supporting 5,000 people, giving annual crops worth £120,000, while without irrigation the same area would not afford pasture for 1,000 sheep.[1]

In **South Australia**, at **Renmark**, there is a prosperous settlement of 3,000 people, where peaches, apricots, raisins, olives, and citrus fruits are grown. The water is pumped

[1] *The Nile of Australia*, by D. J. Gordon, Adelaide, 1906.

from the Murray. In 1916 the exports were valued at £153,000. Fifteen inches of water per acre per annum can be supplied for 12s. or less. Numerous small settlements along the **lower Murray** are being irrigated. Among these are Waikerie, Moorook, Berri, and Cadell.

Irrigation in New South Wales.

It is only lately that the Government of New South Wales has wakened up to the necessity of conserving the river waters, which when in flood are a source of actual damage as well as of potential loss. Private enterprise has shown the way. Sir Samuel McCaughey near Narandera has given a striking example of the economy of irrigation. He has estimated that two-sevenths of the waste flow of the Murrumbidgee would irrigate over 2,000,000 acres for cereals to a depth of 4½ inches. This should give 40 bushels of wheat to the acre, or a gross return of nearly £9,000,000.

The results obtained by this stock-owner have largely influenced the Government policy. Now one large scheme has been carried out on the Murrumbidgee River and two others are proposed on the Lachlan and Murray respectively (see Fig. 43).

The **Burrinjuck**[1] **Dam** is situated on the Murrumbidgee, a little below Yass. Here the river narrows to a gorge as it cuts across the elevated peneplain. The drainage area is 5,000 square miles, and the dam conserves all the most important inflows except that due to the Tumut River. The dam will ultimately be 240 feet high, and will store 20 square miles of water, or a much larger area than Sydney Harbour. The water will reach back over 40 miles

[1] The etymology of this word is doubtful. The hills on either side of the dam were called Barren Jack and Black Andrew. Perhaps the latter is a native name also!

up the main stream, and will thus form a magnificent artificial lake.

The river channel carries the conserved waters for 200 miles, almost to **Narandera.** There an offtake leads the water along the northern bank to the distributing canal, where it flows for 100 miles through 750,000 acres of irrigable land. [On the southern side near the Yanco Cut another offtake will supply 912,000 acres to the west of Yanco Creek.] The heavier soils will grow wheat, while vegetables and fodder (sorghum, maize, &c.) and fruits such as those grown at Mildura will undoubtedly flourish. The country is also found very suitable for dairying and pig-raising.

Of the proposed reservoirs not yet authorized it will be sufficient to mention two, of which the first is *Cumberoona* above Albury, at the head of the Murray. Here a dam 70 feet high would impound two-thirds of the water held by the Assuan dam, and it would serve to water the level country around Deniliquin (see Fig. 43). In the central portion of New South Wales a second suitable catchment area (3,200 square miles, the same as Cumberoona) could be utilized at *Wyangala*, above Cowra, on the Lachlan. Assuming that a dam 155 feet high had been in use for 10 years prior to 1901, it would have been full at the end of that year, and instead of a dry channel beyond Condobolin there would have been a volume of no less than 20,000 cubic feet per minute available for stock and domestic supply as far as Oxley.[1] Thus thousands of sheep would have been watered during the great drought, and the dam would probably have paid for itself in that way in a few years.

Western Australia.

In Western Australia, nearly 400 miles inland from the coast, in a region which before 1892 had been crossed only

[1] McKay, ibid.

by a few explorers and prospectors, where the rainfall (8 inches) is almost negligible, is clustered a community of mining men. The chief town, Kalgoorlie, has a population of 30,000, and the other large centres (Coolgardie, 15,000, Kanowna, 12,000, &c.) have a total of about 35,000. The question of water supply was one of great difficulty. At first, condensers were used to obtain fresh water from the local supply of brackish water in salt-pans and shallow lagoons. This, of course, necessitated the carriage of fuel, and the charge to consumers was nearly 7*s.* per 100 gallons. Naturally, this added enormously to the cost of living, and prevented profitable mining development.

It was decided to bring water from the wetter regions near the coast. Early in 1903 the **Goldfields Water Supply** was completed, connecting a reservoir near Perth with Kanowna, 387 miles east of that town. On the Darling Ranges near Perth there is a rainfall of over 20 inches, and a weir across the **Helena River** (at Mundaring) impounds 400,000,000 gallons. **Nine pumping stations** elevate the water 1,313 feet to the Coolgardie distributing reservoir (see Fig. 56) at Bullabulling. The pipe-line (33 inches diameter) is laid on the surface close to the railway, and at each of the pumping stations, roughly 40 miles apart, the water is elevated about 140 feet, whence it flows by gravity to the next station.

The scheme[1] cost approximately £3,389,000, and can supply 5,000,000 gallons per day, though this is not required. The cost to consumers naturally increases with the distance; at Southern Cross (236 m.) it is 5*s.* per 1,000 gallons, at Kalgoorlie (375 m.) it is 7*s.*, and at Kanowna 10*s.* per 1,000 gallons.

[1] An account of the scheme from an engineering point of view will be found in *Feilden's Magazine*, November 1900.

SECTION III. MINING.

CHAPTER XIX

METAL MINING IN AUSTRALIA

It is obviously impossible to condense into one small chapter a general account of the metal mining in Australia in sufficient detail to be of real value. It appears better, therefore, to choose a few mines which are typical of the various occurrences (see Figs. 3 and 49) and discuss briefly the essential elements of their geological and economic surroundings. The following somewhat arbitrary list will therefore be so treated :

(*a*) The gold-fields of Western Australia.

(*b*) The silver-lead-zinc area of Broken Hill, New South Wales.

(*c*) The Ballarat 'Indicator' Reefs, Victoria.

(*d*) The Alluvial 'Gold-rush' at Poseidon, Victoria.

(*e*) The Cobar Copper District, New South Wales.

(*a*) The Gold-fields of Western Australia.

Referring to the sketch-map (Fig. 44) based on the work of the Geological Survey of Western Australia, it will be noticed that the south-east of the State consists very largely of very old rocks (archean possibly)—so old that the fossil contents, if ever there were any, have been altered beyond recognition. These are largely composed of granite and the allied rock gneiss. This **primaeval 'massif'** is fringed by later sediments on the north, west, and south (indicated by white spaces in the map), which

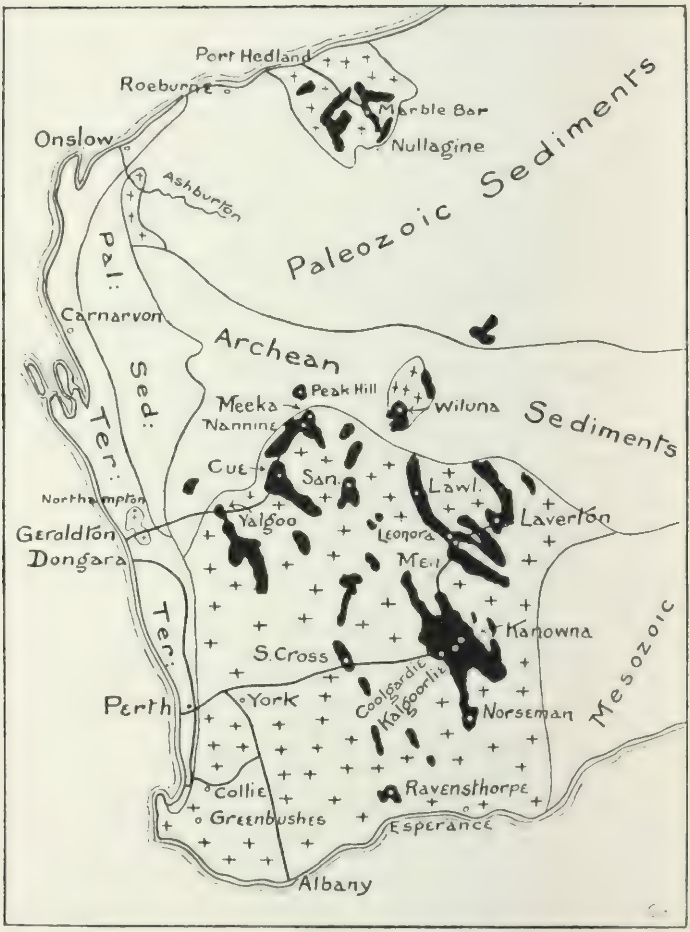

FIG. 44. Geological Sketch-map of Western Australia, showing the chief auriferous areas (in black). These are 'greenstones' which cut across the great granite massif (crosses).

from their fossil contents are for the most part newer than the main 'massif', and may therefore be termed post-archean.

Crossing this exceedingly old series of rocks are many fairly **well-defined belts** running roughly from NNW. to SSE. They consist of **dark laminated rocks** in part, such as hornblende schists, and of various metamorphosed slaty rocks of an allied character. The more eastern belts include the Coolgardie field (see Fig. 44). The western belt—about twenty miles wide—extends from Southern Cross in a northerly direction to Cue and Meekatharra. Isolated examples of the same formation occur at Ashburton and Marble Bar in the north.

There are numerous **auriferous reefs** in these belts, though they are rarely well defined in the west. According to the official bulletin (No. 13) on the Leonora Gold-field, there are two main rock types present, a *granite porphyry*, containing a large percentage of silica, which passes into various altered products, but does not usually appear auriferous ; and a darker *dioritic rock* ('**greenstone**'), which gives rise to the altered greenstone schists in which the chief gold reefs are found (see Fig. 45). The gold occurs in a somewhat exceptional form in many of the West Australian reefs. Usually gold is found nearly pure or alloyed with silver, but here it is often combined with tellurium—a substance allied to arsenic and sulphur.

'The lodes of Kalgoorlie consist of a series of almost vertical banded schistose formations (merely country rock more or less banded by dynamic changes) which have a general trend of from North 30° West to North 50° West. These deposits are lenticular in habit, the lenses being often of great length. Instances occur which go to prove that some of these may reach over half a mile in length. As a general rule the ore deposits have no **well-defined walls**, but seem to pass insensibly into the surrounding rock. The lodes are often traversed by a network of **quartz veins,** which ramify in all directions. There is abundant evidence attesting the fact that the rocks have been subjected to profound dynamic action, which has resulted in the production of lines of weakness along which the mineral-bearing solutions have found a comparatively easy passage. The width of the ore bodies reaches 80 feet in places. The gold occurs free, as tellurides, and as auriferous pyrrhotite.[1] The free gold presents such characters as point to its having been derived from the oxidation of the tellurium-bearing minerals; the decomposition of the auriferous pyrites may also be the source of some portions of it' (A. Gibb-Maitland, Government Geologist).

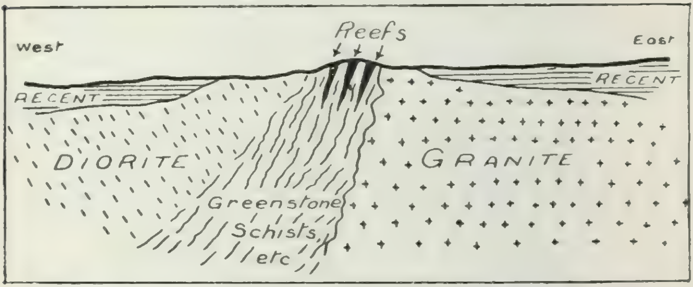

FIG. 45. Vertical Section across the Leonora Gold-field, Western Australia (from the Geological Survey of Western Australia).

At the outset, however, the deposits were discovered and worked as 'alluvial' fields. In 1892 Messrs. Bayley and Ford started on a prospecting trip eastward from **Southern Cross** (discovered in 1888) and reached the native well—**Coolgardie.** Here Ford picked up a half-ounce nugget, and before dinner-time they had found over 20 oz. of gold. A few weeks later they discovered the famous reef, and the same evening they picked up and dollied (i. e. roughly separated) with a tomahawk from the cap of the reef over 500 oz. of gold. **Kalgoorlie** was discovered by Messrs.

[1] Pyrrhotite is a sulphide of iron akin to pyrites.

Flannigan and Hannan in June 1893. Much alluvial gold was quickly taken out and many rich reefs discovered. **Menzies** was discovered in 1894, and in January 1895 there were over 2,500 diggers 'dry-blowing' (separating the gold from the sand, &c., by air-currents) in the vicinity of Kalgoorlie.

The following table from the *West Australian Year Book* gives the relative proportions of gold won in the principal fields, up to 1904 (see Fig. 44):

	Ounces.		Ounces.
East Coolgardie (or Kalgoorlie)	5,846,949	E. Murchison (Wiluna)	440,829
Murchison (Nannine)	1,067,473	Dundas (Norseman)	257,367
Mt. Margaret (Laverton)	916,745	Yilgarn (S. Cross)	241,896
North Coolgardie	913,694	Broad Arrow (near Kalgoolie)	236,267
Coolgardie	724,256	Peak Hill	188,846
North-East Coolgardie	597,122	Pilbarra (Marble Bar)	119,383

Since 1903 the gold yield has decreased from £8,770,719 to £5,140,228 in 1915. The total gold values for the State to 1915 were £125,258,153. In 1915 the chief producers were East Coolgardie, 670,788 oz.; East Murchison, 58,082 oz.; Mount Margaret, 106,563 oz.; and Murchison, 108,049 oz.

(*b*) Broken Hill Silver-Lead-Zinc Mines.

Although this celebrated mine is well within the State of New South Wales, yet practically all communication is carried on through **South Australia**. A glance at the map (Fig. 55) will show that the coast of Spencer Gulf, in South Australia, is only about 200 miles away, while Sydney is more than 500 miles, of which much lies in arid regions. This mining district was first pegged out in 1883. Shares were then sold for less than £100 which some six years later were each worth £2,500,000. The rocks of the district consist of **highly altered slates** and schists, which have recently been classed with the cambrian rocks of the Flinders Range. The lode itself stood out as a ridge of manganese-bearing rocks (gossan). It occupied a 'saddle-shaped cavity formed by the contortion of the strata, and its outcrop formed the highest part of the range for about a mile and a half of its length '.[1]

It appears possible that the lode is a *saddle lode* with two legs diverging downwards and outwards from the cap.

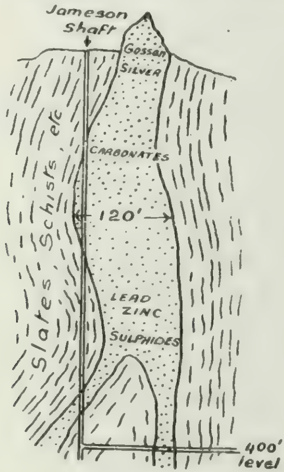

Fig. 46. Vertical Section through the Broken Hill Silver-lead Lode, showing the dominant Features (based on Pittman).

Other writers, notably Professor Gregory, doubt the definite saddle-lode structure and regard it rather as a variety of **fissure vein**. Of course, the importance of the 'saddle-lode theory' is that there is a possibility of the occurrence of similar deposits at lower levels, where similar cavities—due to the contemporaneous folding of lower strata—may have allowed the deposition of metalliferous bodies. Such recurrence has been proved in the Bendigo gold reefs in

[1] Vide *Mineral Resources of New South Wales*, by E. F. Pittman, F.G.S., &c., where a concise general account of the mines may be read.

Victoria, and the rich 'caps' crowning the folds here lie at well-ascertained levels, one below the other, but it may be remarked that the Broken Hill saddle is by no means so well defined as the saddle-reefs of Victoria.

Broken Hill is a good example of the occurrence of the richest bodies of ore at the *surface*, which is opposed to the miner's belief that the chances are in favour of an increase in value with depth. The surface claims were originally taken up for tin in 1883. They were found to contain slugs of '**horn silver**', yielding 55 per cent. of the precious metal. The ore at the upper levels consisted chiefly of **carbonate of lead** with kaolin and other siliceous material, and yielded from 5 to 300 ounces of silver per ton. In this zone, owing to the changes in the ore-body due to atmospheric oxidation and removal of some of the less valuable materials by solution, the metals were more concentrated and more easily extracted than at lower levels. The ore-bodies below the 'oxidized zone' were found to consist of **sulphides** of lead and zinc, with a garnet-bearing siliceous matrix or 'gangue'. Here the character of the ore had changed, for **zinc** reached a percentage of 28, and exceeded that of any other constituent. As the richer ores are practically exhausted and silver values are decreased, it is obvious that the profitable extraction of zinc is now the chief problem of Broken Hill. This was found possible by means of electro-magnets in Wetherill separators, since the zinc blende contains a notable proportion of iron, but the '**flotation**' **process**—where the finely-ground ores are separated through some adhering to oil—has now replaced it.

It is perhaps a legitimate exaggeration to say that Broken Hill started as a *tin* mine, became a *silver* mine, then a *lead* mine, and now depends on the *zinc* for its profitable working.

The population of Broken Hill was nearly 31,000 in 1911. The aggregate output of the mines in little over twenty years was valued at nearly £38,000,000. This settlement in the desert is worthy of some attention from an economic point of view. The annual rainfall is only about 7·9 inches, so that agriculture is impossible. The Broken Hill district forms portion of a **pastoral area** (pp. 106 and 140–1), but it has such arid conditions that, as the Government report states, 'large flocks must be carried to render the holdings profitable, and the western squatter does well to have a substantial sinking fund against the *converse* of a "rainy day".' Hence even the pastoral industry is confined to a few large station holders. The South Australian Government, however, recognized the importance of the mineral field, and by a rapid extension of their railways captured all the trade connected with the industry. A railway of some 230 miles carries the ore and crude metals to Port Pirie (see Fig. 55). It is 150 miles farther to Adelaide. On the other hand, a railway is being constructed from Broken Hill *via* **Menindie** to **Condobolin,** a distance of 300 miles, for the most part across the level western plains, which will thus link it to Sydney. In addition it will form a new through route from Sydney to Adelaide, but one which is not likely to compete with the present journey of some forty hours *via* Melbourne.

(*c*) The Ballarat Gold Reefs.

A very interesting gold-field in Victoria surrounds the towns of Ballarat and Bendigo. Apart from their present commercial importance, they are noteworthy as being the centres of the **gold rushes** of the fifties which had so much to do with the first real emigration to Australia. The country consists of **silurian slates**, which have given rise to undulating thinly timbered highlands. These slates are much folded and faulted, and are covered in the valleys with **alluvial clays** derived from them by weathering. Permeating the slates are numerous **quartz veins**, undoubtedly due to the deposition of silica on the cooling of underground waters. These veins sometimes contain gold, which has also been partly worn away and deposited in pockets on the surface of the rocks with the clay. Hence we have two classes of gold: that occurring in the *reefs* together with much quartz and found at all depths as far as the shafts have been sunk; and the *alluvial gold*, which occurs in shallower deposits, freed from much of the quartz 'gangue'.

As an example of the reef gold the Ballarat 'Indicator' reefs may be instanced; while the biggest 'rush' of late years at Poseidon gives a good idea of the way alluvial is worked. (See (*d*) below.)

Ballarat is an exceptionally well favoured mining city. It has a **rainfall of 27 inches**, the same as the central plain of England, and an elevation of 1,400 feet. It is very healthy. Large crops of potatoes and oats are grown. Gold, however, is the most important asset, and over £70,000,000 have been obtained.

The alluvial diggings, where many of the largest nuggets were found, are not very important now. Most of the gold is won from the reefs. Some of the shafts are over 2,000 feet deep, cross-drives being cut at intervals to tap the various quartz veins or reefs. One peculiarity in many of the mines is the presence of '**indicators**'. The most important is a band of carbonaceous shale, often containing some pyrites, which is interbedded with the slates and is only $\frac{1}{8}$ inch thick. The slates lie more or less vertically, for the strata have been much folded. The **quartz veins** in many instances form more or less horizontal sheets, which cut the slates at right angles.

They are associated with volcanic dykes and are often bounded by a leathery layer of clay which is known as a '**leather jacket**'. Where the quartz reefs are intersected by the indicator valuable gold 'pockets' and 'bonanzas' occur. Here the quartz is extremely rich and the gold can readily be seen glistening in the face of the workings, a by no means common sight in a gold mine. The dark layer in the slates (the indicator) can be traced for long distances, and so it acts as a guide to the miner. There are several of these indicators of varying

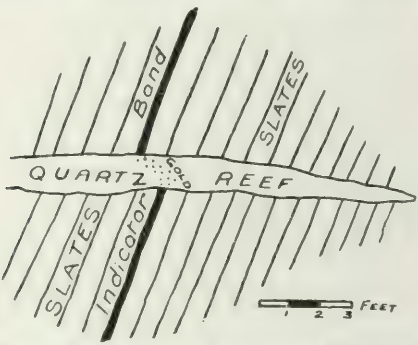

FIG. 47. Vertical Section in a Portion of a Ballarat Mine, showing the occurrence of the rich ore where the horizontal quartz reef cuts the Indicator.

width, and they have tended to make gold-mining in Ballarat a less uncertain and haphazard undertaking than is usually the case.

Undoubtedly the presence of the gold is due in part to the **precipitating action** of the 'indicator' bands on the gold-carrying solutions, which percolated along the crack now occupied by the quartz reef. Experiment has shown that gold will deposit from solution on carbonaceous matter as well as on many metals and metallic compounds, a fact of which advantage is taken in several methods of gold extraction. In the figure annexed (Fig. 47) it will be noticed that the quartz vein occupies a fault plane where the slates have been cracked across and displaced to one side. This is very usual, the gold-bearing solutions naturally finding their way along old lines of weakness.

(*d*) Alluvial Gold at Poseidon.

At the height of the 'rush', early in 1907, the writer and a friend visited this field, which is situated near the Loddon River, twenty miles west of Bendigo (see map, Fig. 43). A short time before several large nuggets, one worth more than £3,000, had been obtained; but such finds are by no means as common now as they were in the fifties. Naturally, as the district lay so close to a town of 40,000 inhabitants, it was quite settled. The lucky miners who got there first were for the most part farmers from the adjoining townships. They were well used to pick and shovel, for they often go 'prospecting' during the slack season at the farm.

The actual scene of operations was a large thinly-grassed paddock with numerous gaunt gum trees, under which the tents of the miners were pitched. A slight ridge marked the course of a **quartz reef** which had been worked out many years ago. Towards the end of 1906 a prospector put down auger-holes along a course parallel to the reef (as at A), until he found the underground rocky channel which had originally drained the ridge. Here he pegged out his claim, and in the stiff red clay, within a foot or two of the surface, several thousand pounds' worth of the rare metal were dug up. His friends immediately pegged out their 60 feet × 60 feet claims as close as possible to his. Those who happened to be on the line of the underground channel (or 'lead') were handsomely paid for their labours—those a few feet away got practically nothing.

The 'lead' rapidly deepened to 60 feet within half a mile, and here the gold was in smaller slugs and not so plentiful. The clay was dug up very carefully and carted a mile or more to the Loddon River, where it was washed in rather primitive circular timber puddlers. The clay was gradually swept away to the river, and the gold collected in the bottom of the puddler.

Two features stand out in the picture of this particular field. Although the miners lived in tents and had to buy their water at a penny a bucket, yet provisions and supplies could be obtained at ordinary prices from two stores, while bakers' carts called regularly from the neighbouring towns.

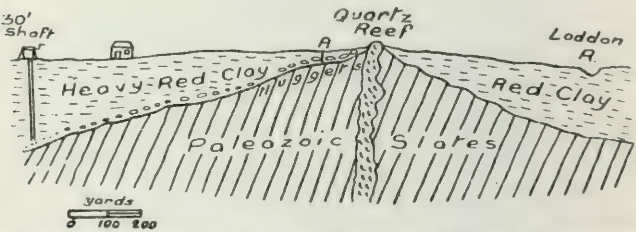

Fig. 48. Diagrammatic Vertical Section of Alluvial Diggings at Poseidon, Vic., along the course of the underground channel.

Although owners of claims along the 'lead' made much money, many of the others were content to hasten slowly, and their holdings were merely 'shepherded' by agents from 11 a.m. till noon (when the law requires representatives to be on the claim) to prevent jumping. The owners were waiting until their neighbours' work should reveal whether it was worth while to pay the extra charges for actually 'breaking ground', and to sink the shaft which was necessary to reach the gold above the bottom rock.

(e) The Cobar Copper Mines.

Just as the discovery of the valuable silver-lead ores of Broken Hill led to the profitable settlement of the extreme Western portion of New South Wales, so the presence of large masses of copper ore at Cobar has contributed greatly to the opening up of the middle west of the State. If the reader refers back to the section dealing with the main geological features of New South Wales (Fig. 29), he will find that Cobar is situated just where the **palaeozoic rocks** (which constitute the Eastern Highlands) emerge from the later sediments which cover their flanks. The region is akin to the Highlands, but not of them, for it is a comparatively level plain with no hills of any importance. As the rainfall is under 15 inches and the soil poor, the vegetation consists chiefly of isolated eucalypts or stunted gum scrubs.

Owing to the valuable mineral contents of this barren surface it has become one of the most important mining centres in Australia; since in addition to Cobar, Nymagee, and numerous other copper properties, many gold mines such as Mt. Boppy (perhaps the most important in the State) have been opened up in recent years.

Although the main Western railway line extends to Bourke, yet by far the greater traffic branches off at Nyngan to Cobar and its neighbours. The great demand for fuel for the **blast furnaces** has led to the destruction of all the larger trees for miles around, so that the district has a blighted appearance. Yet in a good season wheat will grow—and the writer vividly remembers the bright green appearance of a field of young wheat, though no grass was visible in the neighbourhood. The ore was discovered in 1869, owing to the presence of green and blue stains in a native well. It was extremely rich, as may be gathered from the fact that, in spite of the cartage of over 250 miles to the railway, handsome dividends were obtained.

It is very interesting to remember that at this period several thousand tons of ore were sent by team to *Bourke* and thence down the Darling and Murray by steamer to Adelaide. So that at first Cobar, like Broken Hill, was commercially nearer to Adelaide than Sydney. Now the railway from Sydney extends a little beyond Cobar. The Company has a refining plant at **Lithgow**, about 350 miles away, near Sydney (see p. 203), hence it is evident that the Cobar traffic bulks considerably on the main Western line.

As in Broken Hill and most copper and lead mines, the character of the ore varies with the depth. The walls enclosing the ore-body consist of **altered slates**, probably silurian in age. The ore masses are much wider at the deeper levels than the outcrop would indicate, a fortunate but rather exceptional condition. The upper portions consist of **copper carbonates** with a more or less ferruginous gangue,[1] lower down at 250 feet the carbonates and oxides are mixed with the unaltered sulphides, while at the lowest levels (over 600 feet) the stopes (or workings) are cut in solid masses of yellow **copper pyrites**. It is a strange experience to visit these huge artificial caverns, one of which in 1904 was 370 feet long, 25 feet high, and 60 feet wide. They are comparatively free from timbering, since the ore 'stands' well without support. In these large spaces, however, it is difficult to work the ore, and sooner or later probably the empty stopes will be filled with 'mullock', or waste material obtained during mining operations.

[1] Iron-bearing country rock.

The chief mining fields of Australia (see Figs. 3 and 49) are as follows:

Gold: *West Australia*—East Coolgardie, Ora Banda, Murchison, Mount Margaret. *South Australia*—Tarcoola (*Northern Territory*—Pine Creek and Tanami). *Victoria*—Ballarat, Bendigo, Ararat, Chiltern, Maryborough, Wal-

FIG. 49. Minerals other than gold of Australia.

halla. *New South Wales*—Cobar, Canbelego, Hillgrove, Araluen, Wellington. *Queensland*—Charters Towers, Mount Morgan, Gympie, Ravenswood, Cloncurry. *Tasmania*—Beaconsfield.

Copper: *West Australia*—Ravensthorpe, Mount Malcolm. *South Australia*—Wallaroo, Moonta, Yelta. *Victoria*—Walhalla. *New South Wales*—Cobar, Kyloe, Cangai. *Queensland*—Cloncurry, Mount Morgan, Chillagoe. *Tasmania*—Mount Lyell, Mount Balfour.

Tin: *West Australia*—Greenbushes. *South Australia*—(Mount Todd in Northern Territory). *New South Wales*—Tingha, Emmaville, Ardlethan. *Queensland*—Herberton, Chillagoe. *Tasmania*—Mount Bischoff.

Silver lead: *New South Wales*—Broken Hill, Yerranderie. *Queensland*—Chillagoe. *Tasmania*—Zeehan, Dundas.

Opal: *New South Wales*—White Cliffs, Lightning Ridge. *Queensland*—Opalton.

Iron: *South Australia*—Iron Knob. *New South Wales*—Cadia. *Tasmania*—Penguin.

Salt: *South Australia*—Lake Fowler.

CHAPTER XX

COAL IN AUSTRALIA

In Europe and most of the coal centres of the Northern Hemisphere, the chief **coal-bearing rocks** are characterized by a fairly uniform set of fossils which have been termed *carboniferous* for that reason. In the Southern Hemisphere the most valuable coal is found in beds slightly newer than these. This coal is assigned to an intermediate position, the **permo-carboniferous**. It is characterized by certain ferns with tongued-shaped leaves (*Glossopteris*). In Australia, India, and South Africa there are valuable coal deposits of this age, and these fields are also characterized by the presence of glacial boulders and other common features. The economic geology of the Australian coalfields therefore differs greatly from that of Europe, and beds which in Europe would be associated with coal are devoid of it in the Southern Hemisphere.

There are also coal-bearing strata in much younger rocks, but the coal is of a much poorer quality.

Coal, as opposed to most metalliferous deposits, occurs in more or less **horizontal beds** or seams. In most cases it is derived from the carbonaceous material of enormous **swamps, peat-bogs**, and coniferous forests, which were buried long ages since, by later silt and sand. Subsidence and further deposition has piled thousands of feet of fresh material above the ancient peat deposit, **consolidating** it, and often altering its constitution by squeezing out volatile matters, or leading to the distribution of tarry substances through the whole. In many cases no doubt the coal plants grew where the seam now lies, since the 'underclay' is often deficient in the amount of plant foods, and crowded with fossil roots. Often, however, ancient floods undoubtedly swept organic débris into some depression in the bog. The accompanying silt gave rise to those worthless 'bands' in the coal which so greatly decrease its economic value.

Coal in Australia, as elsewhere, varies very greatly in appearance, composition, and economic value. Before describing the chief deposits a few remarks on the method of testing and classifying coals will help the reader to appreciate their characteristics.

The value of coal is tested in the following manner. A definite amount is ground up and weighed. It is then heated to drive off **water** and weighed again. The poorer coals contain a very large proportion of water, which lessens their value as a fuel, since this must be evaporated before the coal is of use. Then the weighed coal-dust is heated red hot in a closed vessel, which, however, permits the escape of the **volatile gases**. From diminution in weight the percentage of the latter can be calculated. The character of the residue shows if it be a **caking coal**; for then a vesicular lump of coke will have formed of a nature suitable for metallurgical purposes. Finally, the coal is intensely heated with free access of air. This burns away all the **fixed carbon**. It leaves only the ash, which, like the moisture, is another harmful compound, since it often contains substances injurious in metallurgy, causes clinkers in the grates, and is useless bulk in freight wagons.

A usual classification of coal based on the foregoing is as follows, determined by the percentage of **volatile gases** or hydrocarbons:

Name of Coal.	*Percentage of Hydrocarbons.*	*Other Characters.*
Illuminating Coals . .	45–29 %	Should be low in sulphur.
Metallurgical (giving dense and coherent coke)	29–17 %	Should be low in ash and sulphur.
Steam Coals	17–10 %	Used in boilers.
Anthracite	10 % and less	Smokeless and less bulky.

Distribution of Coal in Australia.

The States richest in coal are New South Wales, Queensland, and Tasmania. The first has by far the greatest output, as the figures for 1914 show :

	Output.
New South Wales	£3,737,761
Queensland	416,292
Victoria	289,099
West Australia	148,684
Tasmania	27,853

Referring to Fig. 49 A the main (permo-carboniferous) coal-bearing strata are seen to occur along the **eastern shore** of Australia. In North Queensland are three small basins of no importance at present, Oakey Creek and Little River, behind Cooktown, and at Townsville. The Blair Athol seam at **Clermont** is 66 feet thick, and is very productive. Next comes the large undeveloped basin of the **Dawson River**, which contains excellent coal, some of it almost anthracite. Just within the New South Wales boundary is a relic of the eroded coal preserved at Ashford. South of this area is the most important coalfield, the **Newcastle-Lithgow-Bulli** Coal Seams, which, with their associated strata, cover an area of 25,000 square miles, and yield £3,500,000 worth of coal per annum. In Tasmania unimportant fields of this age occur near the Mersey River in the north and at Port Cygnet in the south. The chief coal supply in this State is from later sediments.

Of deposits of later date, the most important occurs in Southern Queensland around **Ipswich**. To the east of the permo-carboniferous basin there occurs an area of triassic

Fig. 49 a. Chief Coalfields (after Prof. David). Permo-Carboniferous (P.C.) seams are black.

coal which supplies the Queensland market, and has led to the establishment of a considerable manufacturing centre at Ipswich. In the southern extension of these deposits in New South Wales there are a few seams of no great value, which are by no means comparable either in extent or in composition with the Ipswich coal. At **Burrum**, near Maryborough, are seams of cretaceous age.

Of somewhat similar mesozoic age are the small deposits of **Leigh's Creek**, in South Australia, where an enormously thick deposit of moist, poor coal is found, and the Gippsland coal at Outtrim and **Wonthaggi**, near C. Paterson, Victoria.

More important mesozoic coals, however, occur in Tasmania and Western Australia. At **Fingal**, in the east of Tasmania, a very flourishing coalfield occurs, whence 90 per cent. of coal won in the State is derived. In Western Australia a useful supply is obtained at **Collie**, in the south-west corner. It lies in a small basin scooped out of the ancient 'massif' of Western Australia, and so has not been subjected to earth movements.

Where folding has taken place, the coal is as a rule more compact and contains less water and volatile matter. Hence the excellent quality of the **Ashford** coal (New South Wales) and of portion of the Dawson River coal (Queensland). But the undisturbed coal at **Collie** has not been improved by the 'kneading of Mother Earth' and is therefore very wet and somewhat clinkery.

Passing to the tertiary deposits, the main Victorian seams at **Morwell**, 88 miles east of Melbourne, are of this late period.[1] The coal is friable and moist, and has therefore been 'briquetted' or compressed into bricks after being dried. In this condition its value is greatly enhanced, but even so it cannot compete with the Newcastle coals, except quite locally. These facts are summed up in the following table, which gives fairly representative figures but does not pretend to great accuracy.[2]

[1] This deposit is of enormous size, several layers of brown coal being 100 feet thick and one reaching 700 feet!

[2] In part based on data given by Professor David in a lecture to the University of Sydney Engineering Society.

Locality.	*Age.*	*Character.*	*Composition.*				*Potentialities.*
			Water	Vol.H	F.C.	Ash	
Newcastle	Permo-carboniferous.	Very good steam coal for boilers, domestic use, gas, &c.	1·9	35	54	9	Exported very largely, gives best coke.
Lithgow	do.		1·9	31·5	52·6	14	Not exported, as 100 miles from coast; used in metallurgy.
Bulli	do.		1	23	65	11	Used for coke and export.
Ashford, New South Wales	do.	Excellent coal	0·71	22·9	69	7·5	Useful on northern railway.
Dawson, Queensland	do.	Excellent coal, high % fixed carbon	3·7	13	78	5	Very promising field for export and local use.
Ipswich, Queensland	Trias	Used for all purposes	1·5	28	62	8	Two seams, 11 ft. and 4¼ ft. Supplies all Queensland.
Collie, West Australia	do.	Hydrous, brittle when dried	15	25	53	6·7	Supplies West Australia.
Fingal, Tasmania	do.	Like Ipswich coal	—	—	—	—	Supplies Tasmania.
Gippsland	do.	Poor coal	6	32	55	7	—
Leigh's Creek	do.	49 ft. of soft coal	17·7	27·3	42	13	400 mls. inland, very clinkery.
Wonthaggi	Jurassic	Friable	4·9	34·3	51·4	9·3	Usually thin seams.
Morwell, Victoria	Tertiary	Very hydrous and crumbly	46	32	16	4	Usable when briquetted after drying.

As the chief coalfield in the Southern Hemisphere, some further details of the New South Wales Basin are shown in Fig. 50. This is a diagram representing a model cut across from west to east to show vertical sections along two lines.

In the west the basin is bounded by silurian (?) slates, which also form the bed rock below the coal measures.

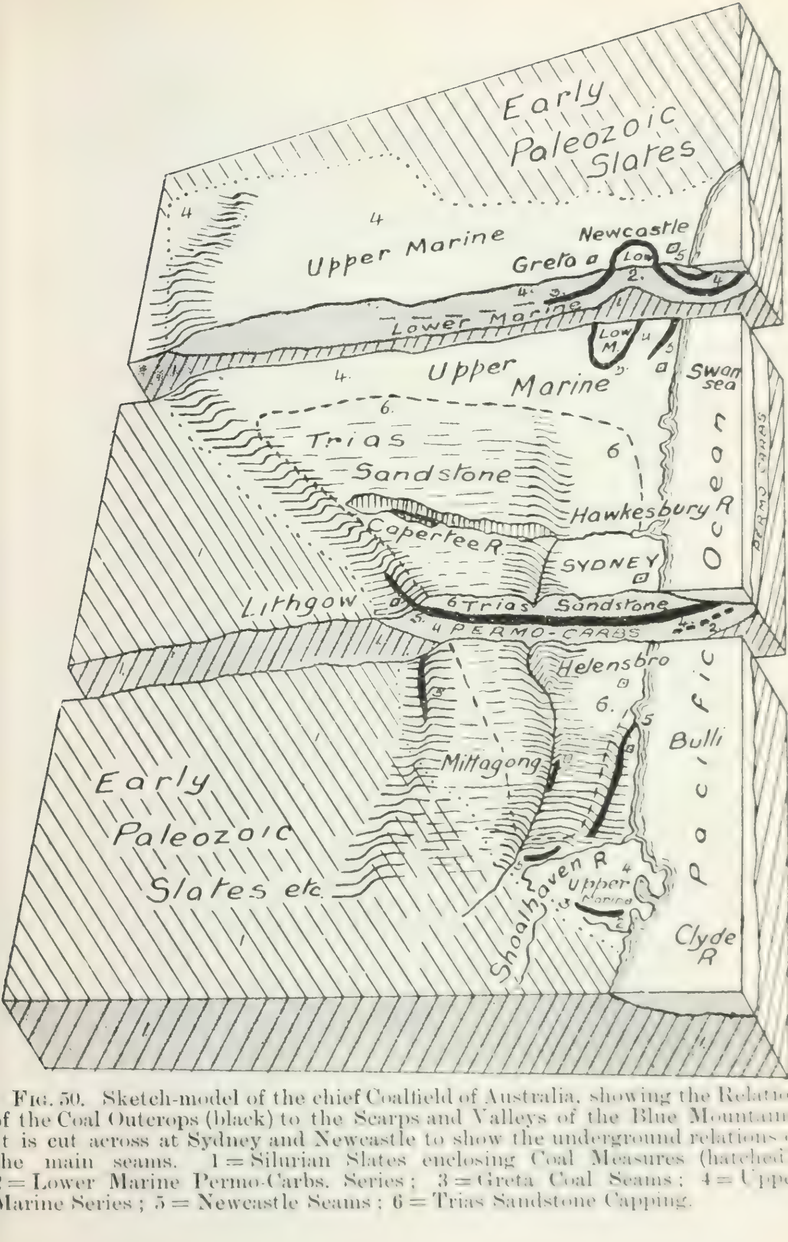

FIG. 50. Sketch-model of the chief Coalfield of Australia, showing the Relation of the Coal Outcrops (black) to the Scarps and Valleys of the Blue Mountains. It is cut across at Sydney and Newcastle to show the underground relations of the main seams. 1 = Silurian Slates enclosing Coal Measures (hatched); 2 = Lower Marine Permo-Carbs. Series; 3 = Greta Coal Seams; 4 = Upper Marine Series; 5 = Newcastle Seams; 6 = Trias Sandstone Capping.

Immediately above this oldest formation comes the marine series marked (2) known as the **lower marine**[1]; they are nearly 5,000 feet thick. Above it is the **lower seam** which crops out at Greta, where an upward bulge or dome in the crust occurs; it forms an important part of the field, for the workable coal is about 20 feet thick. Here is the most important coal area in Australia. It extends for 15 miles, from West Maitland to Cessnock. It also appears far to the south at Clyde River, but is not yet worked there.

Later 5,000 feet of the **upper marine** series (4) were deposited. Immediately above it lies the most important series of seams known as the **Newcastle-Bulli coal**, which seems to form a huge black saucer, extending under the whole of the country from Newcastle to Lithgow in the west and to Bulli in the south.

By remarkably acute geological induction, the credit of which is due chiefly to Messrs. Clarke, Etheridge, and David, it was inferred that this coal would be found a few thousand feet **below the capital city, Sydney.** In 1890 a bore was put down at North Sydney and struck coal at 2,801 feet. A company has since put down two shafts in Balmain, alongside Sydney Harbour, so that 'the largest ocean steamers can load their cargoes of coal from the colliery's wharf in Sydney'. To the south of Sydney, at Helensborough, this same seam is worked profitably at 850 feet. At Bulli and allied collieries the coal crops out **at the side of the Coast Range**, and can be seen as a broad black band.

On the **western side** of the field, the coal crops out in the deep gorges excavated by the rivers flowing to the Hawkesbury. Here adits[2] in the river valleys at **Mittagong**

[1] The lower marine series seems to have been overlapped by the upper marine series for a great portion of the basin. It outcrops best in the east, near Newcastle and the Shoalhaven River.

[2] An adit is a more or less horizontal passage usually opening in the face of a hill.

furnished coal for the first smelters of iron. At Lithgow, on the western flank of the Divide (see Fig. 50), the coal comes to the surface and has led to the rise of one of the chief manufacturing centres in Australia. Here is situated the only large blast furnace (Sandford's, 1907), and several metallurgical works chiefly connected with the copper industry.

Mr. E. F. Pittman (Government Geologist of New South Wales) has estimated the coal resources as follows:

	Sq. miles.
Productive area of Upper Seam (Newcastle-Bulli) . .	15,800
Productive area of Lower Seam, in north (Greta) . .	250
Productive area of Lower Seam, in south (Clyde) . .	500
	16,550

The maximum thickness of workable coal is about 120 feet. Assuming there is only 10 feet of workable coal over the whole 16,550 square miles, he[1] estimates that there are 115,346,880,000 tons of available fuel, which is nearly that of the coalfields of Great Britain.

In the Capertee valley, which opens to the Hawkesbury, is one of the largest deposits of kerosene shale in the world. It is shown as a black band in the cliff, in Fig. 50. About 50,000 tons, valued at £27,000, was won in 1914.

Overlying all the coal seams is an upper 'saucer' of barren sandstone of triassic age, of which the chief buildings of Sydney are constructed.

[1] See *Mineral Resources of New South Wales*, by E. F. Pittman, A.R.S.M.

SECTION IV. OTHER INDUSTRIES OF AUSTRALIA

CHAPTER XXI

TIMBER AND SUGAR

In this chapter several of the typical minor industries will be described. Those which present most points of interest, in the writer's opinion, are the following: Australian Timbers, the Sugar Industry, and the Fisheries.

The Timber Industry.[1]

Australia has the smallest amount of timber-forest in proportion to her total area of all the continents. The true forest area is less than 4 per cent., which is the same as Britain. Germany has 26 per cent., U.S.A. 34, Sweden 52, and Japan 56 per cent. of the total area. (H. R. Mackay.)

The forest reserves are distributed as follows:

	Acres.
New South Wales	5,764,125
Victoria	4,160,342
Queensland	4,076,335
West Australia	1,610,435
Tasmania	1,019,449
South Australia	147,380

The only States which have developed a large commerce in timber are **Western Australia** and **New South Wales**. The former exports timber worth more than £500,000 a year, but New South Wales only one-half of that. The western State has paid more attention to the exporting of timber, which is largely controlled by the

[1] This is treated fully in recent memoirs by D. E. Hutchins (Perth, 1916); and Vic. Forestry Conference, 1917.

English capital of the Jarrah Company. Although the timbers exported from the two States are almost all members of the Eucalypt family (allied to the myrtles botanically), yet the genera are quite distinct. For instance, *Eucalyptus crebra* (Ironbark), *E. microcorys* (Tallow-wood), *E. punctata* (Grey Gum) are very important trees in New South Wales; while *Eucalyptus marginata* (Jarrah) and *E. diversicolor* (Karri) are the chief timbers exported from Western Australia.

The **eucalypts** have lanceolate leaves, rich in essential oils, with both surfaces alike. The flowers are usually not very conspicuous and are generally greenish or white. They are great favourites with bees, and many a bare rocky slope which will only grow stunted gums is of value to the bee-keeper. When young the trees are very graceful and bushy, but, unless topped, usually become somewhat gaunt and straggly in their old age. The local names are mainly based on the **character of the bark**—which is usually renewed annually. Thus the smooth barks belong to the *gums* (grey, blue, and red), the corrugated barks denote *ironbarks*, the fibrous barks are *stringybarks*. Their aromatic properties, quick growth, handsome appearance, and valuable timber have led to their plantation in many parts of the world, such as California, New Zealand, South Africa, and Italy.

The eucalypts attain their most vigorous growth in **temperate regions** and require a fair rainfall, though many of them can flourish in dry surroundings that would dishearten any other tree. For instance, in the arid regions of South Australia (north-east of Lake Torrens) the country is largely a stony waste with a few stunted mulgas. Yet here and there a line of large eucalypts mark out a '**gum creek**' or dry river, where the deep roots of the 'sugar gum' are able to tap the moist subsoil.

Western Australia.

In Western Australia, as elsewhere, the distribution of timber is mainly controlled by climate. It is bounded on the east by the **15-inch** isohyet and extends north to latitude 30° near the Irwin River (see Fig. 51). Within these limits are found splendid forests, of which the jarrah and karri are undoubtedly the most important. There are, however, several other timbers of great value. Along the coast, for instance, is a narrow belt of **Tuart** (*E. gomphocephala*). This tree attains a height of 160 feet and a diameter of 7 feet near the ground. It is especially suitable for framing, possessing a curly grain which makes for toughness.

The great **Jarrah belt** lies to the west of a line joining Perth to Albany, and chiefly on the eastern side of the Darling Scarp. Its area is estimated at 8,000,000 acres. About 60,000 acres per year are cut, and it is considered that there are thirty years' supply. Though not such a large tree as the karri, jarrah is one of the most handsome and durable timbers in the trade. It constitutes by far the largest proportion of the timbers exported, for it is in great demand for street-paving and piles, while it makes excellent railway sleepers, probably unexcelled.

The **Karri Forests** lie to the south of the State, between the Blackwood River and Albany, the best occurring in the valley of the Warren, where there are about 1,000,000 acres of this fine tree. It grows to a height of 300 feet and attains a diameter of 17 feet at the base. It is very strong, tough, and elastic, and is therefore well suited for bridges, shafts, and allied work.

On the eastern flank of the Darling Range are found two valuable trees, the **Wandoo**[1] and the **York Gum.**[2]

[1] Wandoo or White Gum is *E. redunca.*

[2] York Gum is *E. loxophleba.* Mallet Gum, Salmon Gum, Gimlet, and Sandalwood occur in this belt also.

They are smaller than the preceding, reaching a height of 75 feet, with a diameter of 20 inches. Both are dense hardwoods. The former is used largely for props in mining, and both are suitable for general wheelwright

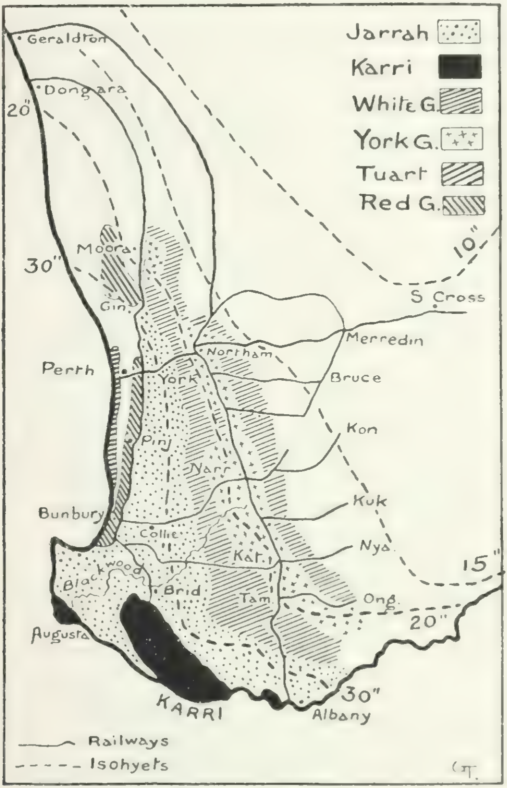

FIG. 51. Timbers and Rainfall of Swanland (W.A.). The drier areas and much of the eastern gold-fields are wooded with Salmon Gum and other eucalypts, which are used for mining timbers. The whole area over 10 inches will probably grow wheat. The new railways in the wheat belt are shown.

work. Their distribution with reference to the 20-inch isohyet is well shown in Fig. 51.

An estimate made some years ago put the areas as follows:

	Acres.	*Loads.*
Jarrah	8,000,000	40,000,000
Karri	1,200,000	15,000,000
Tuart	200,000	300,000
Wandoo	7,000,000 }	7,000,000
York Gum, &c. . . .	4,000,000 }	
		62,300,000

The late Conservator of Forests estimated the value to the State of forests on Crown Lands at £124,000,000.

New South Wales.

Largely owing to the researches of Messrs. Maiden and Dalrymple Hay, the physiography of the timber areas in New South Wales is perhaps better known than in any other State. The accompanying figure shows how greatly the timber belts depend on rainfall (refer to Fig. 52). The 10-inch isohyet defines the western limit of the forest area, and the 20-inch line the western boundary of the Highland timbers. In the north is a zone of Brush timbers of especial interest, on the eastern flanks of the New England Plateau. Along the coast is a well-marked province known as the Coastal Zone.

As might be expected, the various timbers are not altogether confined to any one district. For instance, **ironbark** is found all over the north and east of the timber area, and **grey box** has a similarly wide range. The **yellow box** favours the western slopes of the divide, while the **stringybark** is most common on the eastern. **Blue gum**, **turpentine**, and **mahogany** are practically confined to the coastal area. **Murray red gum** occurs only in the Riverina. **Cypress pine** is characteristic of the Western Plains, where the forests are sporadic.

The most characteristic area is that known as the **Northern Brush.** Here are some of the largest areas of ancient lava (basalt), which make a fertile soil. This, combined with the heavy rainfall in this region, has led to a forest growth far more luxuriant than anywhere else in the State. Here a sub-tropical flora, consisting very largely of soft woods, flourishes. The most highly prized is the magnificent red cedar, a timber of great value in ornamental joinery. Other woods with a beautiful grain are rosewood and tulipwood, while sassafras and yellow-wood, which also grow on the basalt hills of the Blue Mountains, are used in cabinet work.

The following table, due to Mr. J. H. Maiden, F.L.S., shows the economic characteristics of these timbers :

Name.	*Characteristics.*	*Use.*
Ironbark	Strength, durability, weight	Girders, sleepers, framing, shafts.
Stringybark	Easily split	Fencing and building, sleepers.
Mahogany (Blackbutt)	Strength and durability	Paving, building, sleepers.
Tallow-wood	Durability, greasy nature	Decking, girders, piles.
Grey Box	Toughness, coarse grain	Naves, mauls, sleepers.
Blue Gum	Straight grain, easily worked	Building, planking.
Turpentine (*Syncarpia*)	Resists decay and white ant, non-inflammable	Piles, sleepers, paving.
Murray Red Gum	Strength, durability, resists white ant	Piles, ground timbers, paving, sleepers.
	Soft Woods	
Cypress Pine (*Callitris robusta*)	Durability, fragrance, resists white ant	Linings, framing. (Western Slopes.)
Red Cedar (*Cedrela Australis*)	Lightness, easily worked, handsome figure	Furniture, joinery. (North Coast.)
Rosewood (*Dysoxylon*)	Rose fragrance, and fine working qualities	Furniture, boxes, &c.
Tulipwood (*Harpullia*)	Toughness, ornamental grain	Cabinetwork, billiard-tables.
Sassafras (*Doryphora*)	Lightness, fragrance	Furniture, cases.
Yellow-wood (*Flindersia*)	Hard, close grain, like beech	Cabinetwork.

So far the **export** of New South Wales timbers has been trifling. Ironbark girders and sleepers have gone to New Zealand and Britain; tallow-wood, turpentine, and blackbutt for paving and sleepers to New Zealand and Germany; and a little ornamental timber (rosewood, &c.) to Germany.

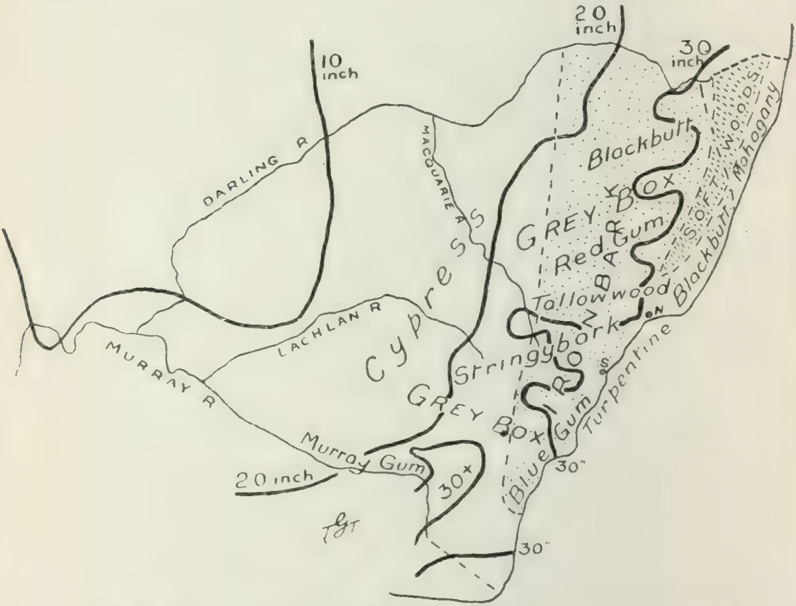

FIG. 52. Chief Timbers of New South Wales. Ironbark area is dotted. Isohyets also shown.

However, the Government is endeavouring to stir up interest in the immense supplies of hardwood. In ironbark New South Wales possesses probably the strongest timber in the world, which at the same time is one of the most durable. For instance, its breaking-strength is double that of English oak.

In **Queensland** the forests are confined to the east coast, where the rainfall is over 25 inches. The **soft-woods** comprise **Pines** (*Agathis* and *Araucaria*), with Cedar, Silky Oak, 'Maple' and 'Beech'. They grow from Cooktown to Townsville with smaller patches behind Bowen and Mackay. A large area of mixed forest occurs south of Gympie. The **hardwood** forests occur through the Eastern Highlands, especially near Atherton, Clermont, and in the Dawson basin. All the south-east corner has a plentiful supply.

In **Victoria** Stringybark (*E. obliqua*) and Messmate (*E. amygdalina*) cover all the Eastern Highlands. On the slopes are Ironbark, Grey Box, Blue Gum, &c. Red Gum grows along the Murray. **Blackwood** (*Acacia*) and Beech flourish in the wet coast ranges.

In **Tasmania**, Eucalypts of fine growth (Blue Gum and Stringybark) occur in the east. Blackwood is a valuable ornamental timber. In the west are **softwood pines** and beech where the rainfall exceeds 50 inches.

Sugar in Australia.

In Australia almost all the sugar grown is derived from **canes**. Attempts both in Victoria and New South Wales with beet sugar have not flourished, though the reasons are not obvious. Cane sugar flourishes best near or between the tropical regions, the chief regions being Cuba, Java, Hawaii, and the Philippine Isles. In Australia, however, we have extensive plantations south of the tropic which may be compared with those of Louisiana in America. Another centre of interest to Australians is Fiji, where sugar is the most important crop. It is evident that, given good soil and a satisfactory rainfall, a wide range of temperature is permissible in sugar-cane planting. This is the case in Australia, where the sugar industry extends from the **Clarence River** in New South Wales **to Cook-**

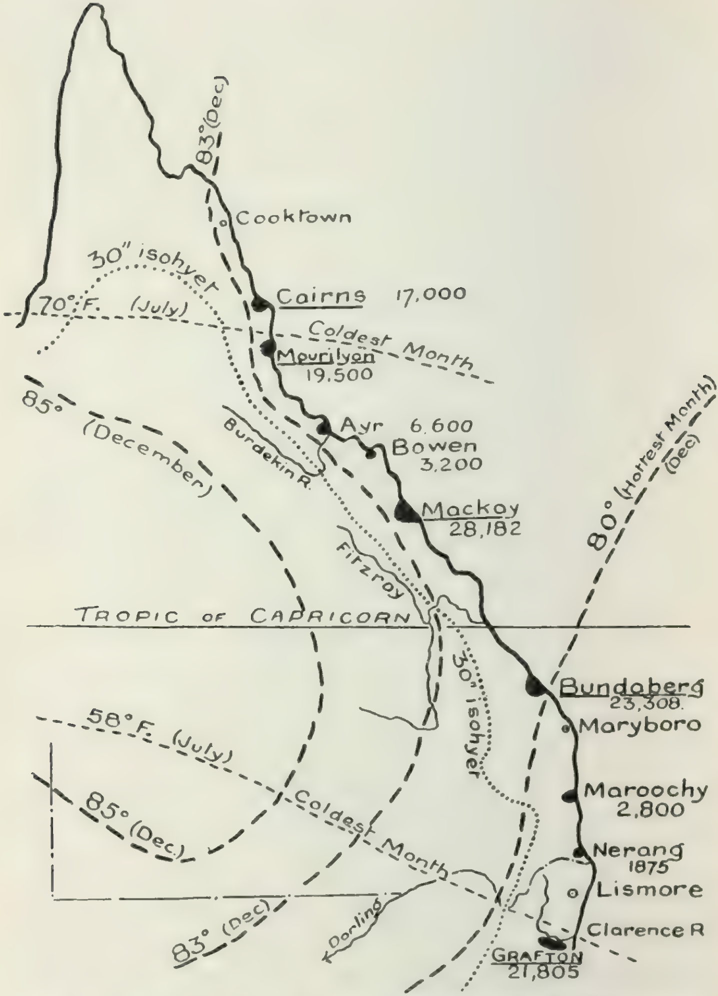

FIG. 53. Sugar in Australia, 1905. (Figures denote acres under cultivation.) Of recent years the production has increased in the north and decreased relatively in the south.

town in North Australia, the mean annual temperature ranging from 68° F. to 80° F.

In New South Wales the sugar-cane is practically confined to the three northern coast counties (Rous, Clarence, and Richmond) centring about Grafton and Lismore. The southern limit is determined by the risk of frost, which has driven the planters northward. In 1895 there were nearly 33,000 acres under cane, but owing to increase in dairying and changes in sugar duties the extent has decreased considerably, and was 11,000 acres in 1915.

The Kanakas (South Sea Islanders) have not been employed very extensively on the sugar plantations of New South Wales, and in 1906 most of them were returned to their original homes.

There are only three mills, near Murwillumbah, Lismore, and Grafton respectively.

It is, however, in Queensland that the chief sugar centres are situated, at Bundaberg, Mackay, and Cairns (see Fig. 53). Thus in 1915–16 there were 153,027 acres under cane, or ten times as much as in New South Wales. The area is much the same as that under maize, and a little less than the wheat acreage, but it should be remembered that sugar is seven times as valuable a crop as wheat.

Sugar Districts and Crops, 1915.

	Acres.		*Acres.*
Brisbane region	3,855	Mackay region	56,224
Bundaberg region	42,789	Cairns region	44,801
Gladstone (on Tropic)	866	Douglas (N. of Cairns)	4,492

The sugar is grown chiefly on the rich soils along the valleys of the coastal rivers. The jungle is cleared away, and the cane propagated by means of short *joints*, each containing a few shoots. Thus a cluster of new canes arises which matures in about eighteen months. In the warmer districts it is possible to cut these canes many years without replanting, but in the south they need fresh plants in three or four years.

In the drier portions of the sugar area, as around Bundaberg, the success of the sugar-cane depends on **irrigation**. The water is obtained by tube-wells, which penetrate the water-bearing strata within about 20 feet. The water is then distributed over the plantations in ditches. The large estates have been largely subdivided in recent years, for the 'White Australia' policy favours the system of farming smaller holdings and selling the standing crop to the mill-owners.

The cane is worth about sixteen shillings per ton delivered at the mill. From four to five shillings per ton of cane is given as a **Government bounty** for cane grown wholly by white labour. There are now about fifty mills in Australia which handle much more cane than when there were eighty, as in 1881. In order to assist the small cane-growers the Government advanced money on mortgages of their farms, to build central co-operative sugar-mills. The cost of these mills ranged from £21,000 for a mill capable of turning out 2,000 tons of sugar during the season, to £60,000 for a 5,000 ton mill.

Referring to the map, it is apparent that the plantations are sporadic and clustered around far distant centres. There seems no reason to doubt that there is a large future before the sugar industry when the lands between these isolated areas are occupied, as similar conditions of soil and rainfall obtain at many intermediate points not yet utilized.

In 1912 the Queensland area under cane amounted to 141,652 acres; the area cut was 78,142 acres, or nearly 55 per cent.

The isotherms for July and December, and the 30-inch isohyet, are plotted on the map. The winter isotherm of 58° determines the southern boundary (Grafton); while the **30-inch isohyet** practically limits the crop to the coast—for the reason that the *rainfall* is closely correlated with the *onshore* Trade Wind belt. In this belt also occurs the only well-watered, rich soil country, since the highlands are much too rugged for sugar plantation, while on the more fertile western slopes the rainfall rapidly diminishes.

The question of the employment of coloured labour in this industry is not within the scope of this book. A *résumé* of the legislation on the matter is given in the *Commonwealth Year Book*, 1908, and a general account of the whole industry in the *Year Book of Queensland*, from which many of the above facts were taken.

With regard to **future extension,** there is not much land in Northern Territory and round the Gulf of Carpentaria which is suitable for the growth of cane.

The six months drought (see Chapter VII) prevents their growing many of the tropical crops except in irrigated regions. So that the sugar belt will long be confined to the east coast.

However, nothing can be done with such crops as require cheap labour under the **White Australian** régime, and until some change takes place many acres of fertile coastlands must lie idle in our tropical north.

The political point of view has been frankly stated by Bruce Smith in his book *The Commonwealth of Australia*. He says, 'Australians keep out coloured labour for political and not for economic reasons. They intend at all costs to preserve the purity of the white race. Australians have already more work than they can do in the more temperate portions of the country . . . [and] . . . are quite content that the development of tropical productions should be delayed' (p. 280).

In Victoria about 750 acres were sown with **sugar-beet** in 1911–12. The chief district is near Maffra in Gippsland, but the industry is not in a very flourishing condition in spite of a Government bounty of £2,244 on 7,481 tons.

CHAPTER XXII

AUSTRALIAN FISHERIES

ALTHOUGH not very largely developed in Australia at the present time, yet several branches of this industry possess a special interest. Each of the States is endeavouring to promote the capture of *edible fish* in their coastal waters; but in the tropical seas the chief attention is paid to pearl-shell, tortoise-shell, and bêche-de-mer, which, from the zoological point of view, are not fish at all.

Referring to a map of Eastern Australia, it will be seen that there is a rugged coast-line and a highland belt parallel to, and at no great distance from it. Along the northern portion is the unique area of coral known as the **Great Barrier Reef.** We have along the east coast a succession of sheltered harbours, many being drowned river valleys, as at Sydney. Farther north, among the reefs of the Great Barrier, is a shallow warm-water area very suitable for the breeding of fish of valuable qualities, as well as of turtle, pearl-shell, and bêche-de-mer or trepang.

The opinion has been expressed that this environment, singularly well fitted for fish-life—both drowned harbours and huge extent of shallow coral sea—is the result[1] of a common earth movement, perhaps linked with the formation of the central lowlands of Australia.

While the Western Plain country (from the Riverina to the Gulf of Carpentaria) was being slowly elevated, thus raising the pliocene and other late tertiary formations hundreds of feet above sea-level—and incidentally altering

[1] Hedley and Taylor, *Coral Reefs*, Aus. Assoc., Adelaide, 1907.

the drainage system of Lake Eyre and the MacDonnell Ranges (p. 124)—in a corresponding zone to the east the country was being submerged. As far as the waters were warm enough (i.e. to 28° S. latitude) the coral polyps built their colonies of lime ; not raising a huge *barrier* above the waves, as many imagine, but forming a series of individual reefs each separated by a mile or two of shallow water, which are perched on the huge bulk of coral *rock*, and in many cases only appear at low tide. If one imagined the level of the sea to fall several thousand feet ; looking from the Pacific, one would see a huge scarp (rising 3,000 feet in about a mile) capped by a low castellated *rampart*, which alone would be occupied by living coral colonies.

It is among these isolated reefs scattered over the surface of the 'shelf'—largely composed of submerged coral rock, partly no doubt formed by the continental shelf—that the **trepang** (bêche-de-mer) fisheries occur. This animal is largely exported to China, but is often used for soup on the Queensland coast. It is neither a fish nor a slug, as it is indifferently called by the fishers, but is an echinoderm, and therefore allied to the star-fishes. As one wades through the tepid waters of the reefs, it is difficult to avoid treading on numerous black or brownish animals —exactly resembling in size and shape a stout large cucumber—which crawl sluggishly over the coral-reef sand. These are the sea-slugs, trepangs, bêche-de-mer, teat-fish, or sea-cucumber, as they are indifferently called. Only certain genera are edible. They have no means of defence, and are obtained in thousands by the blacks. The 'fish' are boiled for a short time and then gutted. After drying they are smoked in a smoking-hut for twenty-four hours. During these operations they shrink to one-third their original bulk and become hard and leathery.

'*China* represents the market to which, with the excep-

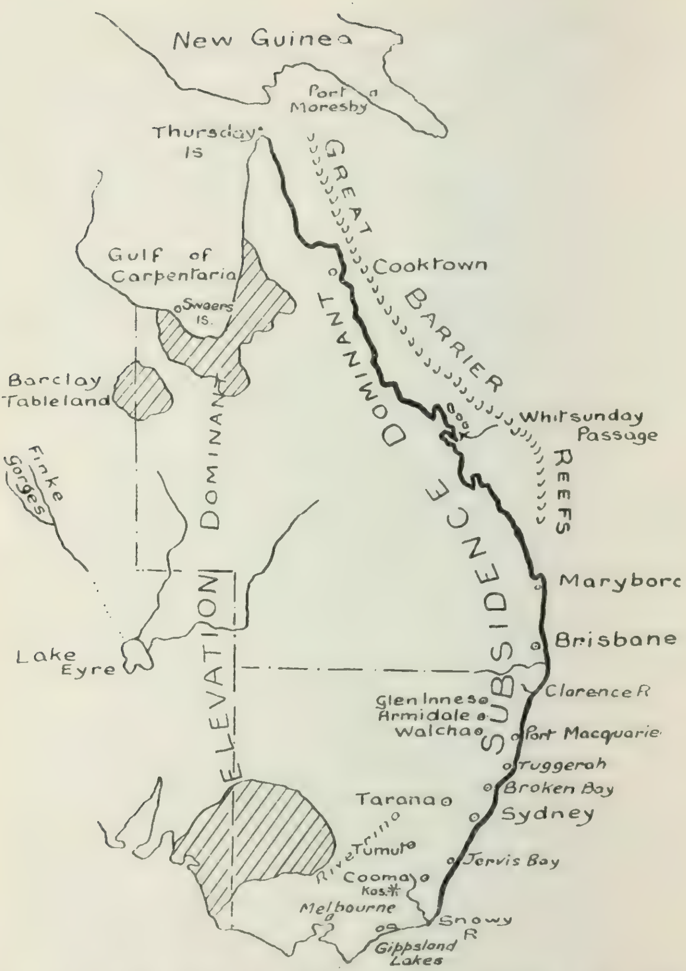

Fig. 54. Sketch-map showing the Areas dominated by Tertiary Uplift and Subsidence respectively. (Elevated sediments of late tertiary age are hatched.)

tion of a few hundredweights, all the Australian bèche-de-mer is consigned, in which market that shipped from Cooktown, and known as "Barrier fish", enjoys a higher reputation and realizes better prices than the article derived from any other locality on the face of the globe. As much as £160 per ton has been occasionally realized.'[1] In 1915 about 100 craft were engaged in the industry and realized £39,918. One ton of cured 'fish' is a good month's take for a party of twenty men and four boats. As may be imagined, this uninviting product needs much preparation before consumption; and if the writer may be allowed to express a personal opinion, the result hardly compensates for the labour involved!

The **pearl** industry of Queensland is confined to the tropical area, and is essentially associated with the Great Barrier Reefs. The head-quarters are on **Thursday Island,** Torres Strait, 30 miles west of Cape York, and from this centre shelling expeditions are made along the mainland coast-line to the northern limits of the Great Barrier and throughout Torres Strait northward to New Guinea. In the Gulf of Carpentaria, also, Saville Kent was able to show the presence of the pearl oyster as far south as Sweer's Island.

The average depth of water from which the greater quantity of mother-of-pearl shell is at present collected is **seven or eight fathoms** (45 feet). Twenty fathoms represents about the greatest depth from which the shell is profitably fished, although few divers can stand the strain of prolonged work under that pressure. The boats employed are of 100 tons burden, there being about 100 in number, while the hands engaged may be computed at 1,000. Saville Kent (whose work on the Barrier Reefs

[1] Saville Kent, *The Great Barrier Reef*, 1893 (fine illustrations).

should be consulted) states that one month's work for a boat would result in a load of 600 pairs of shell, averaging 3 lb. a pair, a total weight little short of a ton.

It is the mother-of-pearl *shell* that is primarily fished for in Torres Straits, the pearls being mostly appropriated by the hired diver and the boats' crews. Not one pearl shell in several thousand produces a large pearl, yet they constitute a valuable asset, and may even be of more value than the mother-of-pearl. Thus in 1904 at Shark Bay (in West Australia) 71 tons 16 cwt. of small shell, valued at £566, yielded approximately £2,000 worth of pearls.[1] But this smaller West Australian variety has more numerous pearls and they are of better quality, though the shell is less valuable than the *Margaritifera meleagrina* of the Queensland coast. Some very interesting details of the habits and varieties of the pearl oyster are given by Saville Kent. He was able to transport the animals alive for considerable distances, and made some experiments on the artificial production of true pearls. Some thus obtained possessed 'a substantial intrinsic value, but . . . it has been deemed scarcely fair to speculating schemers to tantalize their minds with hazy glimpses of a royal road to the rapid accumulation of untold wealth'. So we are left in the dark as to how he produced the large 'bouton' pearl figured in Plate 38!

The value of Queensland pearl-shell for the year 1912 was £92,576, and the pearls (obtained by Japanese divers) are estimated at £25,000.[2]

In **West Australia** the trade centres around Broome, and to a less degree at Cossack and Onslow (see Fig. 27). In 1912, shell worth £420,000 was exported, occupying 400 boats and nearly 3,000 persons, chiefly Asiatics, who are to be replaced by whites. Shark Bay is the habitat

[1] In 1909 a pearl of 32½ grains weight, worth £3,000, was obtained at Thursday Island, and in 1911 one of similar value at Broome.

[2] In 1915 *trochus* shell was also collected to the value of £12,000.

of a small variety of shell, as mentioned previously, for which there is little demand, but it is interesting to learn that the experiments of transplanting the large shell from the north-west have been a marked success, and the young shells are growing vigorously.

The **coasts of New South Wales** are too far from the equator for any of the preceding tropical 'fisheries' to exist. Nor have we in this State representatives of the huge 'banks', which have led to the development of the Newfoundland and North Sea Fisheries of the Northern Hemisphere. During the five years 1900–4 frozen and preserved fish to the value of £782,000 were imported into New South Wales, which is considerably more than the value of what was caught locally (estimated at £500,000). But there are valuable assets—as has been abundantly shown in various departmental reports, and especially by the trawling investigations of the *Thetis*.

Mr. Frank Farnell, who conducted the *Thetis* expedition, writes: 'Fish were caught during night and day, of the best quality and in quantities that I have no hesitation in saying would form a payable basis on which to start commercial operations. Over ninety different species were captured, including John Dory, **schnapper**, sole, flounder, skate, and flathead. . . . Great Britain employs over 200,000 people and 25,000 vessels in this industry, which gathers an annual harvest averaging millions of pounds!'

The **coastal subsidence** mentioned earlier in the chapter has given rise to many fine harbours and land-locked bays, such as Port Stephens, Lake Macquarie, Lake Illawarra, Tuggerah Lakes, Broken Bay, Jervis Bay, Port Macquarie, and Clarence River, near which fish in almost inexhaustible quantities are obtainable at all seasons (see Fig. 54).

An interesting account of the Food Fishes is given by J. Douglas Ogilby, from which the following is derived.[1] At certain seasons our seas teem with herrings of various species, which migrate northwards during the latter six months of the year. The **pilchard** (*Clupea sagax*) is the most valuable, and may later enter into no mean rivalry with its more famous northern relative. The sardine of commerce is none other than the young of the European pilchard, and a large import trade of tinned sardines is carried on in all the States. Among the half-beaks, the **garfishes** (*Hemirhampus*) are delicious fish, and are taken in quantities by special small-mesh nets. None of the fishes frequenting our shores are of such commercial importance as the **sea-mullet** (*Mugil dobula*). During the latter part of summer enormous shoals move northwards to their spawning-grounds; portions break off at different periods to arrive at their special breeding-haunts. Thus in the southern bays this commences in March, but the season grows later as we proceed north, until in the Clarence district June may find the shoals engaged upon the spawning beds. For eighteen months the young mullet remain in the estuaries, where they furnish the pick of the fish consumed. Then they gradually work out to sea.

The **mackerel** family is well represented by *Scomber australasicus*, but their shoals arrive at irregular periods, and the flesh decomposes with such rapidity that great care has to be exercised in selecting individuals for the table. One of the most important families is that of the sea-breams, of which one member, the **schnapper** (*Pagrosomus auratus*), is, without doubt, the best known and most prized of all Australian fishes. In New South Wales the supply of schnappers is almost entirely due to the line fishermen, who seek them on well-known reefs at moderate

[1] Ogilby, 'Fish Industry,' *New South Wales, the Mother Colony*, 1896.

depths, and off rocky points and 'bomboras'. They cure well, and grow to very large size, the younger individuals being known as 'red bream', 'squire', &c.

Of freshwater fish, the most important is the **Murray cod** (*Oligorus macquariensis*), which sometimes reaches 100 lb. weight. It is found in most of the western rivers of New South Wales. The **Australian perch** (*Percalates colonorum*) thrives in estuaries along the coasts of New South Wales, Victoria, and Tasmania, and is said to give good sport to anglers.

Lastly, the **trout** has been successfully acclimatized in many of the streams in New South Wales, Victoria, and Tasmania. Especially is this the case in the district around Mount Kosciusko. Over 140 streams have been stocked with fry, yearling or two-year old trout by the Fisheries authorities. The chief centres are Cooma for the Snowy River, Tumut for the Yarrangobilly River (both in the south); Tarana on the western line for Fish River, &c.; in the north, Walcha for the head-waters of the Namoi (Macdonald, &c.); while many of the streams near Armidale and Glen Innes afford good sport (see map, Fig. 54). The same energy in stocking the rivers is shown by several of the other States.

The *Commonwealth Year Book* gives the following data for 1912. In Australia the fish consumed averages only 1*s.* 6*d.* per head, as opposed to 5*s.* in England, so that the States are trying to encourage local interest in the fisheries.

	Boats.	*Men.*	*Value of Fish.* £
New South Wales . .	615	2,405	149,000
Victoria	721	1,138	89,000
Queensland . . .	311	574	36,000
S. Australia . . .	881	1,194	170,000
W. Australia . . .	271	569	64,000

The total value of the take is over £500,000, but foreign fish was imported to the value of £780,000 in the same year.

SECTION V. TRANSPORT

CHAPTER XXIII

THE RAILWAYS OF AUSTRALIA[1]

I HAVE dealt rather fully with this section because the distribution of population and industries is so closely bound up with the evolution of the railways.

These differ from most important railway systems outside continental Europe in that they are State-owned. Only a few of the railways, usually connected with mining centres, belong to private corporations. In a recent Government publication the mileage is given as over 22,000, the construction of which cost £197,000,000. The railways are apportioned as follows (1916):

				Gauges.		
	Government.	*Private.*	*Total.*	5′ 3″	4′ 8″	3′ 6″ or less.
New South Wales	4,193	303	4,496	45	4,340	79
Victoria	4,100	52	4,152	4,018	—	133
Queensland	4,967	1,484	6,452	—	—	6,452
South Australia	3,026	34	3,060	976	361	1,721
West Australia	3,743	964	4,707	—	411	4,296
Tasmania	562	195	758	—	—	758
N. Territory	146	—	146	—	—	146

The longest continuous[2] journey (3,303 miles) by rail extends from *Oodnadatta*, north-west of Lake Eyre in South Australia, to *Longreach* in Central Queensland (see

[1] See also Fig. 56A.

[2] In November 1917 the Transcontinental line linked up the West Australian lines, so that the traveller can now go from Meekatharra to Longreach, about 4,900 miles.

FIG. 55. Chief Railways of Eastern Australia.

Fig. 55). The latter town is situated on the upper waters of the Barcoo River, which flows into Lake Eyre; so that the complete circuit could be made by returning via the stock routes which connect Central Queensland and the Lake Eyre Basin (see the section on the Artesian Basin and Stock Routes).

It will be profitable, perhaps, to imagine oneself travelling over this route, which circumscribes the most important section of Australia[1] (see Fig. 55).

Oodnadatta is 688 miles north of Adelaide, and is at present the northern terminus of the southern railways. From here a 'Land Grant Railway' to Pine Creek and Port Darwin is proposed, a length of 1,063 miles. 'It is claimed that it will be practicable for passengers and mails to reach Port Darwin by the Siberian Railway route in fourteen days from London, and (by this projected railway) Adelaide in seventeen days. . . . The country presents no great engineering difficulties. For the most part it is one vast plain, with here or there a sand ridge or a watercourse.'[2] On the other hand, as the whole of the country traversed is in rainless or tropical country, it does not seem a very profitable scheme for 'White Australia' to undertake at present. The population in 1911 of the Northern Territory consisted of some 1,730 Europeans, 1,300 Chinese, totalling 3,500 omitting Aborigines. Quoting Mr. Playford (Parliamentary Paper 97, 1892), 'The Territory must have cheap labour if tropical products are to be grown and sold with profit in the markets of the world. European labour is not cheap, therefore if Europeans could stand the climate, tropical products could not be produced at a profit by them.'

Oodnadatta is connected with the southern settlements by a narrow gauge (3′ 6″) railway as far south as Terowie. The first section extends to Hergott Springs. The country is occupied by **sheep stations**, in which large

[1] The writer journeyed from Beltana (near Lake Torrens, South Australia) to Brisbane—the greater part of the above route—in 1906.

[2] From *The Central State*, by D. J. Gordon, 1903.

areas to a certain extent compensate for small rainfall. Some mining is carried on in the interior; at one time the gold-field of Arltunga (see Fig. 28) seemed very promising, but expectations were not realized. The maintenance of the **Overland Telegraph**, and the supply of the sheep stations in the comparatively favourable hilly areas in the centre of the continent, account for most of the traffic. From Hergott the main stock route to Queensland starts.[1]

South of Hergott, the service consists of several trains a week, though the passenger trains do not run after nightfall. The writer visited this area during the summer 1905–6, when it certainly did not show its most favourable aspect. Many of the stations had been abandoned, owing to drought and rabbits, and the chief enterprise centred around **small copper 'shows'**, such as the Ajax (Beltana) and Sliding Rock. After a period of rest the 'blue-bush' (an ally of the salt-bush) would revive again, affording good feed, but the absence of permanent pasture and water, and a rainfall less than 10 inches, would seem to discourage closer settlement.

The writer has a vivid memory of drinking water pumped from copper mines, from alkaline sub-artesian channels, or from aged water-holes. After a heavy thunder-storm, the fresh rain-water was procured with much difficulty from a small shower-bath—the Beltana residents preferring not to endanger their internal economy by too drastic a change in the water supply!

Near Parachilna the Flinders Range on the east assumes a definite direction and elevation, and some of the settlements have a correspondingly better rainfall (Blinman, 13 in.). But the low-lying swampy shores of Lake Torrens —whose waters, I was informed, had never been traversed

[1] This area is well described in Gregory's *Dead Heart of Australia*.

by a boat—have a rainfall of only 6 inches. At Willochra the train was filled with a fine sand, so dense one could hardly see across the car. This was due to an attempt to grow wheat, which broke up the natural surface. Ensuing desiccation converted the soil into a drifting sand of a peculiarly portable character. Yet in exceptional seasons wheat can be profitably grown as far north as this, and at **Quorn** we have left the arid regions. Farther south and considerably to the east is **Petersburg,** an important junction, where the silver-lead from Broken Hill—'the greatest mine on earth', as it has been called—crosses to reach Port Pirie on the Gulf. At Terowie the **broad gauge** (5 feet 3 inches) necessitates a change of cars—which can now run through Adelaide and Melbourne uninterruptedly to Albury. Kooringa is close to Burra, which in 1860 was one of the most **famous copper mines** in the world, but since 1877 little ore has been raised.

The railway passes through the **wheat and sheep** belt, being joined at Roseworthy by the long branch line from Morgan on the Murray. Near Roseworthy are Tanunda (a great **wine district**) and Kapunda, the first copper mine worked in South Australia. A run of 50 miles brings us to **Adelaide,** a remarkably well-designed and handsome city, situated on the plains at the foot of Mount Lofty (2,400 feet), about 5 miles from the coast. It is characterized by its wide streets and abundant parks, and enjoys 'about the lowest death-rate in the world'.

The Inter-State Railway crosses the **Mount Lofty hills** by nine tunnels and a viaduct over 100 feet high. Here are situated the beautiful residences and gardens of the Adelaide merchants. On the western slopes around Reynella and Morphetville are some of the most important **vineyards** in Australia. Some 40 miles east the Murray is crossed at Murray Bridge. The old river swamps are being drained and embanked, and large quantities of **vegetables and maize** are grown in the extremely deep black soil.

After following the Murray for 12 miles Tailem Bend is reached. The branch line from this point to Pinnaroo (90 miles) with several others to Peebinga, Loxton, and Waikerie opens up a huge agricultural district (10–14 inches rainfall) where wheat is grown successfully. Between Tailem Bend and Serviceton (on the border of Victoria) the train crosses what was called the **Ninety Mile 'desert'.** This region is an immense plain of somewhat sterile soil largely covered with mallee. With the addition of superphosphates and its good winter rainfall (Coonalpyn, 17½ inches, Pinnaroo, 16½ inches) this region is fast becoming a prosperous wheat area.

An interesting explanation is advanced by Mr. Howchin, of the Adelaide University, of the **surface limestones** which are so characteristic of the drier portions of Australia. These have a comparatively small depth, but cover square miles of country, following the outcrop of the older rocks below. They furnish a rather poor soil which may be absolutely barren, as in parts of the Ninety Mile Desert and Mallee districts. The **evaporation** due to the heat of the sun is excessive in these regions, and removes all the water in the top layers of the soil. Thereupon the underground waters rise to take its place. These are often charged with small quantities of *lime* and other alkalies dissolved from felspars in the granites, or from other limestones, &c. On reaching the surface, the **lime is deposited** as this water also passes off into atmosphere. The lime-waters will also dissolve silica (sand grains), and so in some regions hard quartzite crusts are formed in the same way.

From Bordertown an important branch line runs south to the isolated district of **Mount Gambier.** This is a volcanic district famed for its crater lakes and fertile soils. It is blessed with a rainfall ranging from 25 to 32 inches, and the summer temperature is the lowest in the State, so that it is much visited as a holiday resort. It is said to be the 'ideal home of the dairyman', and all the English fruits, such as apples, pears, cherries, and berry fruits do well. **Potatoes and onions** are the chief products, however.

Two long lines through Eyre's Peninsula lead from Port Lincoln to Thevenard and Kimba. They open up a fine wheat and sheep region.

Much of the country in North-West Victoria is covered with **'Mallee' scrub**—thickly clustered eucalypts about 15 feet high with characteristically swollen root stocks. This is rolled down by traction engines, or by some similar method, and yields fair crops of wheat. It is reached by many parallel lines leading to Rainbow, Hopetoun, Ouyen (to Pinnaroo), Sea Lake, Manangatang, &c.

The Inter-State Railway gradually rises and crosses the complicated series of highlands, which cannot (in Professor Gregory's opinion) be justly termed the Great Dividing *Range*—since they are composed of such diverse elements from a geographical point of view. At Ballarat we reach the southern portion of the best-known Australian **gold-field**. Here are Dunolly, Poseidon, Bendigo, Maryborough, and many other townships, where huge nuggets were found in the heavy clay soil within a few feet of the surface. Now the mining is chiefly concerned with reefs, and the country is largely occupied by thriving farms. **Ballarat** is an extremely prosperous town, and its citizens would appear to have a keener sense of municipal responsibility in the matter of embellishing their town than is usual in Australia. Fine public gardens, parks, and statues, and the large artificial Lake Wendouree greatly enhance the natural attractions of Ballarat. From here the line descends the Bacchus Marsh scarp to Melbourne.

Professor Gregory, in his *Geography of Victoria*, gives an interesting *résumé* of the **growth of Victorian railways.** This—the smallest mainland State—has as many miles of railways as any of its larger neighbours, and their distribution is closely related to industrial development. Thus 1854–60 is the period of *suburban* lines around Melbourne, including one to the port of Geelong. Some few years later (1862) Ballarat, Bendigo, and other great *mining* centres were being connected to the metropolis. In 1873 the Victorian section to *Sydney* was completed—the Adelaide section, being less important, was only finished in 1887. Lines tapping the southern *agricultural* districts of Sale, Portland, and Colac were completed in the seventies. From 1880–90 the north-west plains (Donald, Boort, and Kerang) were linked up, and the direct route to *Ballarat* over the Bacchus Marsh scarp was opened; the earlier railway was via Geelong. From 1890 the chief railway construction has taken place in the Mallee plains in the north-west.

The Gippsland railway has reached Orbost and another line taps the coal region and dairy area of Wonthaggi and Port Albert.

From Melbourne [1] the main line runs north-east, no important branches leaving on the east where the rugged mountains of Northern Gippsland present exceptional difficulties to the engineer. In the basin of the Ovens River are many **gold mines** where the 'deep leads'—alluvial covered by basalt give employment to a large number of miners at Chiltern and Rutherglen. Dredges also do well, as at Yackandandah, where an extremely small gold content is profitably handled.

At **Albury** the **gauge changes** from 5 feet 3 inches to the standard English width of 4 feet $8\frac{1}{2}$ inches, so that the Victorian cars are left here for those of New South Wales.

[1] Population 628,400 in 1912. In this one centre 45 per cent. of the population of Victoria is concentrated.

Albury is on the Murray, and is the largest town in the Riverina, which lies north and west of it for the most part. Mining (at Corowa), **vineyards, wheat, and sheep** are all important industries in the neighbourhood. On the east of the line are the rugged slopes which culminate in Mount Kosciusko (7,340 feet), and these are not traversed by railways. **Wagga**—with similar industries to Albury—is situated where the railway crosses the Murrumbidgee. From Junee a branch line to Hay passes through country which is **irrigated by the Burrinjuck Reservoir.** At Cootamundra we are in the foot-hills of the Eastern Cordillera, and here a branch runs to **Wyalong,** one of the most satisfactory gold-fields in Australia. At Murrumburrah (Harden) the only **important loop** in the New South Wales railway system occurs. Here it is possible to proceed north to Blayney and thence to Sydney by the Great Western line, passing through Young and Cowra, both rich mining, agricultural, and pastoral districts on the western slopes of the State. On the southern route we proceed eastward to **Yass,** near which is the site of the federal capital, and cross the Divide between the Murray system and the coastal rivers near Goulburn.

The authorities in New South Wales are wisely rejecting the term the Great Dividing *Range*. The terms, Northern, Central, and Southern Highlands or Plateaux of New South Wales may be conveniently used in its place. The term tableland, which has been suppressed, is applicable only to part of these highlands. These three divisions are separated from each other by two broad relatively depressed areas, to which the name *Geocol* has been applied.[1] The Southern line, with which we are at present concerned, traverses the **Lake George geocol** and soon arrives at

[1] *Proceedings of the Linnean Society, N.S.W.*, vol. 31, p. 517.

Goulburn, a town of 10,000 inhabitants, engaged chiefly in agricultural pursuits. Here an important branch line runs south along the tableland to Cooma, the chief town of the **Monaro Plateau,** 2,657 feet above sea-level, and of growing importance as a tourist resort, and the entry to the Snowy Mountains and Kosciusko areas.

The next important town on the main line is **Moss Vale,** which rivals the Blue Mountain district as a holiday resort in summer. It has large areas of rich soil, due to the weathering of volcanic lavas, where splendid crops are grown. The train rapidly descends to the plains around **Camden**—the earliest pastoral settlement in Australia—and thence over the undulating country characteristic of the triassic shales to Sydney.

Sydney, like its friendly rival Melbourne, has a population of over 600,000. (On December 31, 1912, the metropolis, comprising Sydney and the forty municipalities of the suburbs, had a population of 698,800.) The life and industries in the two cities are much the same, the River Yarra and Hobson's Bay being, however, a poor substitute for Port Jackson. The terminus of the lines at Sydney is also more imposing and convenient than the two stations at Melbourne. The latter are to be replaced in the near future by up-to-date buildings. Finally, the main streets of Melbourne are undoubtedly better fitted for the needs of a great city than the comparatively narrow and winding thoroughfares which carry Sydney's main road traffic. 'In the old charts and views, the outline of what is now George Street, and the main artery of the city, may be traced as a winding bullock-track, starting from the vicinity of Dawes Point and pursuing its sinuous way round obstacles and past certain fixed points without any regard whatever to mathematical directness.'[1]

[1] J. M. Taylor, *Geography of New South Wales*, p. 114.

All the railways of New South Wales converge on Sydney, and the **history** of their growth is interesting. The first railway from Sydney to **Parramatta** (15 miles) was hardly well started in 1850 when all the employees ran off to the gold-fields. It was completed in 1855, while the extension to Goulburn was opened in 1869. From 1880-5 the railways were extended to centres already populous and prosperous, viz. Riverina and New England and the central districts of Wellington and Dubbo; also the Murray was crossed into Victoria. From 1885 the extensions on the main lines have for the most part been through **pastoral** country. Mention must be made of the huge **Hawkesbury Bridge**, with the deepest piers in the world, which was completed in 1889, and placed Sydney in communication with Newcastle and Queensland, though the section north of Newcastle to Tamworth had been finished ten years. In 1893 the **South Coast line** was completed to its present terminus Nowra. The later lines are in the west and northern districts, such as those to Condobolin, Coonamble, and Inverell. The only important isolated system in the State is in the extreme north-east, in the **sugar-growing** districts. It links Grafton, Casino, Lismore, and Murwillumbah.

Before continuing our inter-State journey to Queensland, we may glance briefly at the Great Western system. This is a continuation of the original Sydney–Parramatta line, and was carried without difficulty to Penrith at the foot of the **Blue Mountains.** These rise abruptly to heights of 3,000 feet, and presented grave difficulties to the engineers. They were surmounted by zigzags and tunnels in 1876, necessitating gradients as steep as 1 in 30. Comparatively recently extensive deviations have improved these grades considerably. The Western line has led to the growth of an important chain of **summer resorts** some 70 miles from Sydney, of which Katoomba and Mount Victoria are the most important. They are situated on a comparatively narrow ridge bounded by the precipitous slopes of the famous Blue Mountain Valleys. No inconsiderable proportion of the passengers detrain here to visit the **Jenolan Caves,** about 35 miles south west from Mount Victoria, which are perhaps the most picturesque of all stalactite caverns. Soon the line drops down into the **Lithgow** Valley, an important industrial district. **Bathurst** is on the head-waters of the Macquarie, and its plains are devoted chiefly to wheat-growing and sheep. Thence the railway runs to Blayney (and Harden) and Orange—the famous gold-fields of Sofala, Hill End, Hargraves, and Ophir, lying to the north.

A branch line to **Condobolin**[1] passes through mining districts at Forbes and Parkes, and much wheat is grown, though the rainfall is rather uncertain and the crops do not always succeed. Dubbo, on the main line, is situated on the edge of the western slopes, and beyond that the line runs to Bourke across a plain so level that every slight elevation is called a hill. The branch line from Nyngan to **Cobar** is of much greater importance than the main line to Bourke, for a great proportion of the copper and gold in the State is obtained in the mines in and around Cobar, such as Nymagee and Mount Boppy. A line to **Coonamble** from Dubbo taps an important pastoral area, while an important line runs from near Lithgow to Mudgee and Dunedoo, passing extensive mines of kerosene shale near Capertee.

The Northern Railway, after leaving the suburbs of Sydney, passes through the barren, rugged gorges of the Hawkesbury River, which has given its name to the sandstone of which the rocks are formed. After the Hawkesbury River is crossed, the **coal measures** are soon entered and the country becomes much more fertile. The chief occupation is naturally coal-mining, and the increase in

[1] This is being extended to Broken Hill via Menindie.

population during the last few years has been very great. **Newcastle** (with its suburbs) has now 61,400 inhabitants.

The North Coast Railway starts from Maitland, and reaches as far as Port Macquarie. The northern section extends almost from Raleigh to Murwillumbah (see Fig. 20).

From Newcastle the Northern line goes north-west up the fertile **Hunter River flats,** where large quantities of **maize and lucerne** are grown, though floods are an objectionable feature in the valley. North of Scone is Mount Wingen, a 'burning mountain', in its truest sense, since here a coal seam has been burning for many years, whereas volcanoes are not, strictly speaking, burning mountains. At Murrurundi the railway crosses the Divide and reaches the fertile valleys of Quirindi and **Tamworth,** chiefly devoted to **cereals and sheep,** though mining is carried on in the neighbourhood. A branch to **Narrabri** and Moree crosses the northern wheat belt, and an extension to Inverell reaches the chief tin and gem-producing districts in the State.

The railway gradually rises from Tamworth and practically runs along the summit of the northern plateau, which consists chiefly of granite. **Armidale** is the chief town, and squatting and agriculture the chief industries. Extremely rugged country lies to the east of Armidale, and picturesque waterfalls and cañons are numerous. Few important towns are passed before the Queensland border is reached just beyond Tenterfield.

At Wallangarra-Jennings the uniform **Queensland gauge** (3′ 6″) necessitates a change of car, being the third (Terowie, Albury, Jennings) on the 3,000 miles journey to Longreach.[1]

[1] The mail train from Adelaide to Melbourne takes 17 hours, then 17 hours more to Sydney, and 27 more to Brisbane.

Brisbane, the capital of Queensland, is situated much nearer her border than is the case with the other State capitals. Hence a comparatively short journey from New South Wales through Warwick, Toowoomba, and Ipswich brings us to Brisbane. **Toowoomba** is the chief town of the Darling Downs, an elevated country, chiefly basalt, which has a good rainfall, and is one of the most flourishing agricultural districts in Australia. **Ipswich** is the outlet of an important coal-mining area.

Brisbane is situated on a pretty river of the same name, and has a population of 145,000. It ranks with Adelaide, therefore, rather than with Sydney or Melbourne. In Queensland, however, the population is less centralized than in any of the other colonies. It has a long sea-board with good harbours, but a somewhat rugged coast, which leads to railways radiating from the ports rather than a coastal system linking the towns to the capital. Thus the line, extending from Rockhampton 400 miles inland, was completed long before the necessary connexion from Rockhampton to Gladstone, a matter of only 70 miles.

The North Coast Railway keeps near the coast, and passes the well-known Glass House Mountains, whose rounded domes were so named by Cook. It goes through **Gympie**, an important gold-mining centre, and follows down the Mary River, the haunt of the extraordinary lung-fish *Ceratodus*. **Maryborough** is the centre of a sugar-cane-growing district, and has important foundries. The hinterland is rich in valuable timbers, such as *Dammara robusta* ('Queensland Kauri'), while several mining fields, such as Kilkivan, are connected by branch lines. The next large town is **Bundaberg**, another very important sugar district (*vide* the section on sugar). Cattle are very largely bred in the hinterland behind Bundaberg and Gladstone. **Rockhampton** is situated on the tropic of

Capricorn, and is 380 miles north of Brisbane. It lies on the right bank of the Fitzroy River—one of the most important in Queensland—some 35 miles from the mouth. Vessels of 1,500 tons can berth alongside the wharves at Rockhampton. It has a population of 21,000, and is the terminus of the Central Line, extending 428 miles due west to Longreach. Twenty-six miles south-west of Rockhampton is the once phenomenally rich gold-mine **Mount Morgan**—where the gold occurs in siliceous sinter and, according to one theory, was deposited by a geyser. The gold-yield has fallen considerably, but copper ores are abundant at lower levels.

Extensive preserved **meat works** are situated near Rockhampton, which is the natural outlet of one of the chief cattle districts of Australia. On the whole, however, the Central Railway runs through **sheep country**—there being (in 1905) 2,800,000 sheep within a radius of 100 miles of Barcaldine, certainly the densest sheep area in Queensland.

Longreach is the terminus of the long journey which started at Oodnadatta, and which may be tabulated as follows[1]:

	Miles.	*Total Miles.*
SOUTH AUSTRALIA		
Oodnadatta to Adelaide	688	688
Adelaide to Serviceton	193	881
VICTORIA		
Serviceton to Melbourne	289	1,170
Melbourne to Albury	190	1,360
NEW SOUTH WALES		
Albury to Sydney	392	1,752
Sydney to Wallangarra	492	2,244
QUEENSLAND		
Wallangarra to Brisbane	233	2,477
Brisbane to Rockhampton	397	2,874
Rockhampton to Longreach	428	3,302

[1] Since November, 1917, the longest journey is 4,900 miles: starting from Meekatharra to Perth 600 miles, Perth to Port Augusta 1,426 miles, or 2,285 in all to Adelaide.

Of the remaining railways of Queensland the most important are as follows: the *Great Western Line*, 600 miles long, links the pastoral areas of Cunnamulla, Charleville, and Roma with Brisbane; the *Great Northern Line*, from Townsville south-west towards Winton (368 miles), passes through the flourishing reef-mining district of **Charters Towers,** where 'a town of 24,000 inhabitants (including suburbs) has formed itself on the high granite country where Mosman and his mates (the original prospectors) hobbled their horses in 1872, and where in every direction the poppet-heads of famous mines can be seen above the houses. About 5,266,754 ounces of fine gold had been taken from the field up to the end of 1905' (*vide* the Year Book). From Hughenden the railway now (1917) runs west to the mining fields of Cloncurry and Mt. Elliot (Selwyn). It is significant that the two termini—Longreach and Winton—are only 100 miles apart, so that it seems not improbable that Townsville will be connected with the inter-State railways across the level western plains before the coastal railways are linked from Rockhampton to Townsville. On the other hand, it must be remembered that a splendid '**inland sea**' exists within the Great Barrier Reef along the Queensland coast, so that safe and rapid transit by powerful steamers connects all the ports where the railways reach the coast.

From **Cairns** a flourishing railway serves **Chillagoe** and the mining districts near Georgetown. It has been constructed along the Barron Gorge past the Falls where the Barron River drops 600 feet in a series of cascades. Shorter railways at Cooktown and Normanton lead some 50 miles inland, but do not compare in importance with the foregoing.

The isolated position and small extent of **Tasmania** render its railway system of much less importance than

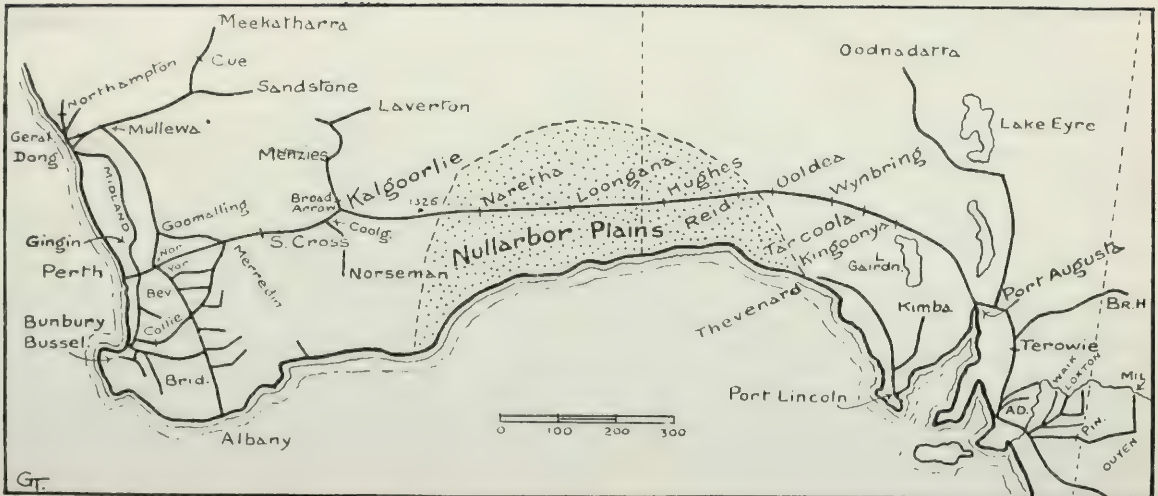

FIG. 56. The Railways of West and South Australia. The treeless Limestone Nullarbor Plains are dotted. Break of gauge occurs at Kalgoorlie, Port Augusta, and Terowie.

those of the other States. The main lines (3′ 6″ gauge) have been mentioned in the preliminary section (p. 93). One feature of interest is the presence of lines with a gauge of only 2 feet—in the mining-fields of the north-west. They are of small extent, however. The mileage has increased but slightly in recent years.

In **Western Australia** (see Fig. 56) the first railways were pushed inland from three widely separated ports. From Geraldton, in 1879, to the copper mines of Northampton; Fremantle to Perth (1881), and extended to Beverley in 1888; and lastly (in 1891), in the agricultural and timber district, from Bunbury to Boyanup. Next a land grant railway was built for 250 miles from Albany to Beverley by a private company in 1889. This was at first an unprofitable undertaking and was sold to the Government in 1896. Another large private line is the **Midland,** running for 277 miles northward. This was constructed under a concession of 12,000 acres of land for every mile of railway, and unites the Geraldton system to the Perth railways. The nineties were marked by extensive construction directly dependent on the mining industry. Thus in 1894 the line to **Southern Cross** was completed, and gradually extended, as the value of the gold-fields became assured, to Kalgoorlie in 1897, and Menzies in 1899. Within the last few years this line had reached Laverton, 595 miles from Fremantle. A parallel development has taken place in the **Murchison gold-field** farther north, the railway reaching Cue in 1898, and Nannine in 1903. Two short railways of much economic importance traverse the south-west; one from Boyanup to Bridgetown, tapping the richest timber districts; and the other from Brunswick to Collie, which supplies most of the coal used on the Western Australian railways. These two lines were completed in 1898.

The mileage in West Australia has been greatly increased in recent years, especially in the **wheat belt.** A long line parallels the Midland from Northam to **Mullewa**; while a perfect network covers the south. Thus cross-lines now connect Bunbury with Narrogin, and also with Katanning. From the Albany line there are six **eastern branches** extending to Bruce Rock, Corrigin, Kondinin, Kukerin, Nyabing, and Ongerup (see Figs. 51 and 56).

The Trans-Australian Railway.

This new line connects Kalgoorlie with Port Augusta. It is owned by the Commonwealth and interposes 1,051 miles of **standard gauge** (4′ 8½″) between the narrow gauges of West Australia and South Australia. The junction was effected at **Ooldea** (S.A.) on October 17, 1917. Three through trains a week are run from each end, and the distance is covered in about 35 hours.

The line traverses a **granite plateau** for 167 miles east from Kalgoorlie. Here it rises to 1,326 feet, the highest point. This section is scattered with salmon gums, gimlet-wood, and sandalwood.

The **limestone plains** differ greatly. There is hardly a eucalypt for 450 miles till the mallee gums of the Ooldea sandhills are reached. Casuarina, myall, and mulga are fairly common, while saltbush and bluebush grow below these. The Nullarbor Plains are treeless, and do not carry much grass. Saltbush is abundant, however. The limestone receives all the rainfall into its hollows, and there are no river valleys or catchment areas.

At Ooldea 50 miles of **sandhills** is traversed. These run mostly across the line, and gave much trouble to the engineers. They are covered with small trees, such as mallee and casuarina.

The hundred miles west of Tarcoola consists of **red soil plains,** well timbered with oak and eucalypts. It is fine pastoral country. At Wynbring the **granite** is reached again, and here (at Wilgena) is the first sheep station. Tarcoola gold-field is near.

The **lakes** are mere shallow salt-pans of enormous extent.

At Kalgoorlie **water** is obtained from the Gold-fields Supply. At each end of the line dams have been built to collect rain, but this is not possible in the central 500 miles. Here bores have been driven down 500 or 600 feet and obtained brackish water. Nearer Port Augusta bores and wells have given good supplies, as at Kingoonya.

The chief benefits of this line are to draw West Australia and the other States into closer relationship, to afford a safe and rapid means of conveying men and arms in case of foreign attack, and to save two days in the delivery of mails.

The region is one of low but reliable rainfall, and though it is doubtful if agriculture is possible anywhere along it (except perhaps in the extreme east), it opens up many pastoral areas of undoubted value.

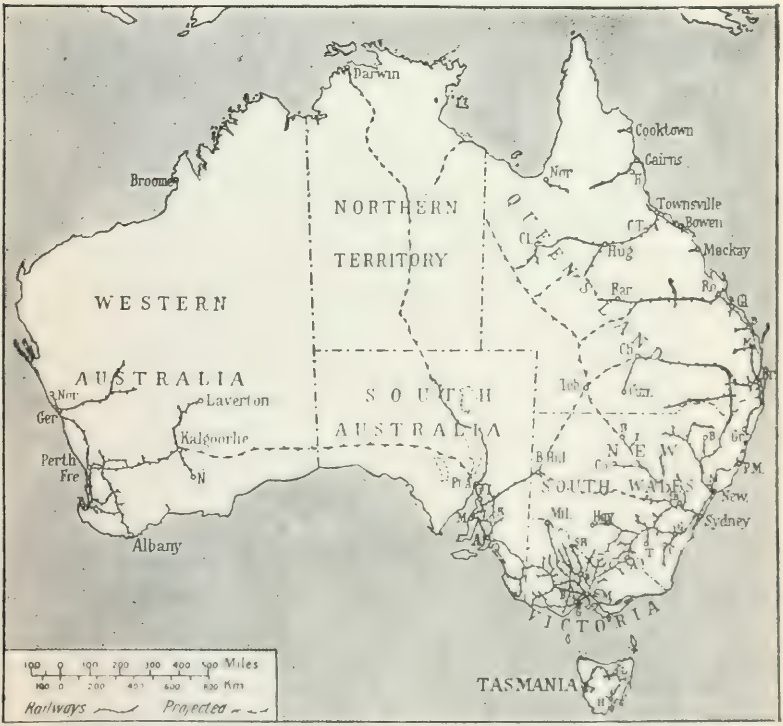

FIG. 56 A. Railways of Australia, including proposed lines. See Chapter XXIII.

CHAPTER XXIV

INTERNAL NAVIGATION

In consequence of the general aridity of the continent, there is little possibility of canalization in Australia. In the vast central area, water is lacking not only for transport, but even for vegetation, as explained previously. However, in the south-east portion of the continent there is one large river-system which in time of average rainfall is used considerably for navigation. This is, of course, the **Murray-Darling system**, which forms the natural outlet for the produce of the Riverina and Western Plains of New South Wales.[1]

An extremely interesting series of articles, published originally in the Adelaide newspapers, has been issued separately under the title *The Nile of Australia* by Mr. D. J. Gordon,[2] to which the reader is referred for greater detail than follows below. The paper on the Murray basin by R. T. McKay, referred to in the section on irrigation (p. 172), will also be found very profitable reading in this connexion.

Some figures given in the latter article are of interest. 'The Murray basin covers an area of 414,253 square miles, being almost three times the size of Japan, which has a population of 46,000,000 of people—whereas not more than 500,000 people are living within the Murray basin area.'

[1] Along the North Coast are some fine waterways, such as the Roper, Adelaide and Victoria rivers.

[2] Published 1906 by W. K. Thomas of Adelaide.

It must be remembered, however, that some of this area is situated within the 10-inch isohyet; while Japan is favoured with an average rainfall of over 60 inches! Such facts as these are constantly overlooked by patriotic Australians in their estimates of the future prosperity of the Commonwealth.

FIG. 57. Navigable Rivers of South-East Australia. (Railways to river towns also shown.)

Gordon (p. 3) describes the **course of the Murray** as follows: 'After beginning its long and tortuous journey to the sea in the Snowy Mountains, near to Mount Kosciusko, the Murray steers a northerly course. Before

Albury is reached, the swollen waters of the main stream turn towards the setting sun, and start on their great westerly course between Victoria and New South Wales. From Albury to Wentworth, a distance of 850 miles, the fall of the Murray varies up to a maximum of 9 in. to the mile; and from Wentworth, for the remaining distance of 617 miles, the fall is never greater than 3 in. in a mile. Even in flood-time the current is slow, and engineers regard this fact as an important consideration in support of a system of locks.'

Speaking of the **Darling**—the largest northern tributary of the Murray—Mr. Gordon writes: 'From Mungindi, in New South Wales, to Wentworth, the Darling has a length of 1,350 miles. The general fall of the river is about 3 in. to the mile, and the velocity, even in flood-time, is only about 3 miles an hour. The channel is clearly defined by banks from 30 to 40 feet high in places. In times of big floods the river overflows, and the waters cover the low-lying lands for many miles. Steamers have been navigated from 20 to 30 miles away from the channel on the flood waters. In 1870 a steamer went from the Darling, along the course of the Paroo to beyond the Queensland border, a distance of 180 miles. The spread of water was then *about* 60 *miles wide*.'

Two episodes in Australian history are of especial interest in this connexion. On February 11, 1830, **Sturt** and his companions reached the sea in their whaleboat, which had carried them for thirty-three days down the Murrumbidgee and Murray. Even at that early period the difficulty of navigation at the Murray mouth was recognized. He writes: 'Immediately below me was a beautiful lake (*Alexandrina*) which appeared to be a fitting reservoir for the noble stream that had led us to it [but] . . . I immediately foresaw that in all probability we should be disappointed in finding any practicable communication between lake and ocean.' They then turned back, and, after enduring great hardships on starvation rations, succeeded in reaching Sydney, 'having unlocked to the world Australia's largest river-system.'

The next chapter of history relates to the first successful navigation for commercial purposes. Captain Cadell in 1851–3 spent much time preparing for a bold attempt to obtain the Government bounty of £4,000 offered 'to the first steamboat which should succeed in navigating the Murray from Goolwa to the Darling'.

We read of his reconnaissances in a canvas boat; whenever she leaked, 'we clapped the frying-pan on the fire, and after cooking our mutton chops, gave her a coat of tallow-grease, which was at all times effectual!' In 1853 the steamer *Lady Augusta* 'was pushed through the sea mouth' and reached Swan Hill (at the mouth of the Loddon) in Victoria. The first cargo comprised wool of the Murray, Darling, and Murrumbidgee rivers.

The Murray and its main tributary, the Darling, are intermittently navigable for no less a distance than 2,500 miles; but with the exception of a simple lock at Bourke, little has been done to extend the period when these streams are capable of being utilized as a channel of trade to the interior. However, New South Wales has expended a quarter of a million, and the other States lesser sums, on such river works as have been done.[1]

Australians are not yet fully awake to the relative costs of carriage by water and rail. A well-known authority (Dr. Rose) sums up a report on Continental Canals thus: 'A comparison of the two methods of transport is altogether in favour of the waterways—a fact which seems to be much more keenly appreciated on the Continent than in

[1] All interested in this phase of Australian life should read *The Dreadnought of the Darling* by Bean (Rivers).

the United Kingdom' (and one might add, in Australia). 'A canal-ship of 600 tons carries as much goods as sixty railway wagons, requires only one-thirtieth of the hauling power necessary on level railroads, is one-third cheaper in carriage per ton, and is worked at a lower rate of expenditure for men and materials. In Germany the cost of transport *per mile and ton* is stated to be less than one farthing. France has spent over £100,000,000 and is contemplating the further expenditure of £20,000,000.'

The Royal Commission which discussed the problem in Australia has made some definite rulings and elicited much information on the important question. I have made free use of their report in the following paragraphs.[1]

As the **river-borne traffic** of the Murray and its tributaries is almost entirely controlled by South Australia, the question is one of importance to that State. Such was sufficiently obvious in the arguments during the Inter-State Commission, where the amount of the water to be diverted by the States of New South Wales and Victoria for irrigation was closely discussed. The New South Wales view of the question (where naturally enough *railway* transport is to a certain degree favoured by the authorities) is ably summed up by Mr. McKay.

'The trade consists of carrying stores to the towns, stations, and settlers located on the banks of the rivers, and bringing back wool, hides, tallow, and small quantities of farm produce. The trade of the Lower Murray and the river-borne traffic of the Darling centres in Morgan. The Upper Murray trade—which includes the river-borne traffic of the Murrumbidgee, Edwards, and Wakool rivers—centres in Echuca, where excellent accommodation exists for the discharge and shipment of cargo.

'With a high river the Murray is practically navigable as far as Albury, but there is very little traffic beyond Echuca, which is 666 miles from the South Australian

[1] In 1914 it was decided by the States concerned to proceed with the locking of the Murray.

boundary. On the Darling steamers trade as far as Walgett, a distance of 1,180 miles from Wentworth. The Murrumbidgee is navigable to Narandera, but it is only on rare occasions that steamers go beyond Hay.

'The gaugings at Morgan show that the **Murray** is, on an average, navigable for about **seven months**—July to January, inclusive—in the year. The **Darling**, however, only provides for **very intermittent navigation**, and it is not an uncommon sight to see boats stranded in the river channel for months at a time. Of late there has been a marked diminution in the volume of trade entering South Australia. This is due to the fact that owing to the drought the rivers have remained unnavigable for long periods, and also to the extension of railways. The Murray is now tapped by **railways** (see map) at Murray Bridge and Morgan in South Australia, and in New South Wales and Victoria the railways reach the river at Mildura, Swan Hill, Koondrook, Echuca, Cobram, Yarrawonga, Corowa, and Albury. The Darling is also tapped at Bourke, Brewarrina, Walgett, and Collarendabri, and railways are proposed to connect Wentworth and Wilcannia. With regard to the Murrumbidgee, the South Western Railway line, which runs parallel to, and at a short distance from, the river, fulfils all the requirements of the trade of the Riverina country.'

The following returns, furnished by the Collector of Customs at Adelaide, will show the great **decrease** in the South Australian river trade with regard to inward and outward shipping, and the value of the imports and exports.

Year.	*Tonnage.*		*Imports.*	*Exports.*
	Outward.	*Inward.*		
1883	28,556	29,733	£664,167	£355,035
1892	23,504	23,345	425,706	131,293
1901	11,215	11,731	137,304	45,327

This is largely due to the *differential railway rates* for *river-district* produce which obtain even in South Australia. Thus it is stated that sugar sent to Echuca costs 50*s.* a ton if for *local* consumption; but if for the *Darling districts* it is carried for 11*s.* per ton, in order to compete with the cheap freight by the alternative water carriage. It must be borne in mind that a river must be 'efficient' before it can expect to become a profit-making means of transport. Hindered by a succession of dry seasons, culminating in 1902, the trade has been heavily handicapped. The sanguine anticipations of low rates competing with railway freights will not be realized until a system of locking the rivers provides not only for this difficulty, but for the more important one of irrigation. The Commission I have quoted so frequently made the following estimate of the cost of necessary works:

	Distance Miles.	*No. of Locks.*	*Cost.*
Between Blanchetown and the border of South Australia	230	6	£600,000
From South Australian boundary to Echuca (Murray)	660	20	730,000
From Wentworth to Walgett (Darling locks)	1,180	24	920,000
From Murray Junction to Hay (Murrumbidgee locks)	238	9	321,750
	2,308	59	£2,571,750

Adding the lower course of the river (to Lake Alexandrina) we get a total length of 2,500 miles rendered navigable at a cost which will reach £3,000,000.

The question as to whether this is a legitimate investment of public funds can only be considered in connexion with that of **irrigation.** Under present conditions, where all the centres of population, except Menindie and Wentworth, are served by railways, it seems distinctly unprofitable. But having in view the flourishing settlements at Salt Lake City, to quote a single instance, where irrigation has made the desert bloom, one may hope good things from the locking of the rivers.

SECTION VI. FORECAST

CHAPTER XXV

FUTURE CLOSE SETTLEMENT IN AUSTRALIA

HAVING now completed our brief survey of the interaction of environment and industry in Australia, we may well devote some time to a consideration of future settlement in the Commonwealth. No one can prophesy where profitable mining fields are likely to occur, but it is doubtful if more than **two per cent.** of the population has settled in purely mining regions.[1] Hence we may primarily confine our attention to settlement due to agricultural and pastoral industries. Since the latter does not lead to *well-populated* districts in the strict sense of the word, we are more or less confined to regions where the climate is suitable for **general farming** and agricultural operations—in fact, to regions resembling those older countries where our white kindred have built towns and founded flourishing and well-established communities. The coalfields will be considered separately.

For the purpose of comparison we shall find it useful to turn to the **United States** of America. Here we have a country colonized by similar races, and situated in somewhat similar latitude. The relative areas are singularly alike, the United States, excluding Alaska, comprising 2,970,230 square miles, and Australia 2,974,581.

Unfortunately for Australia, the vital factor, rainfall, is by no means so generously allotted to the southern land. Probably **only one-tenth** of the U.S.A. has an annual rainfall of less than 10 inches, while in Australia over

[1] See Bulletin 14 (G. Taylor), 'Control of Settlement,' p. 30.

1,000,000 square miles, or 37 % of the whole, consists of such arid country (see Fig. 58).

One of the most promising features of Australian growth is the way in which some of those in authority are cheerfully facing the fact that Australia *is* a land of drought as

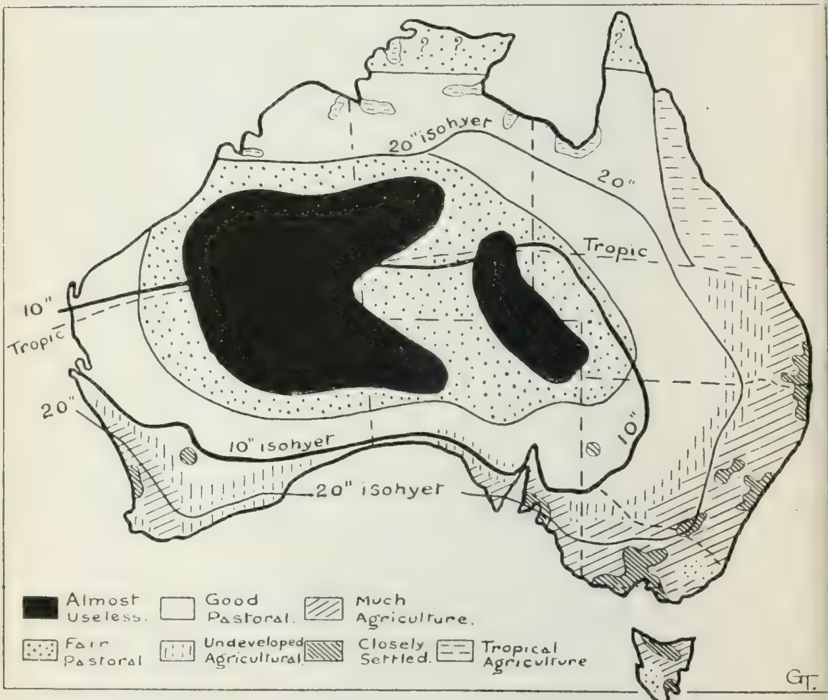

FIG. 58. Potential Occupation of Australia. Regions suited for tropical agriculture are merely indicated along northern rivers. The black areas and most of the dotted area are useless in dry years.

regards a large portion of its area. One could point to good results already resulting from this recognition. The danger of over-stocking in New South Wales is much less than was the case formerly. Money is being spent on water conservation on a much larger scale than ever before. **Railways** which tap the main wool-growing districts are being pushed forward to move sheep to areas of better pasture in time of drought, and so on.

Still, many people do not realize that **rainfall** is of paramount importance for all industries except mining. It seems a trifle misleading to publish comparative maps of Western Australia (for instance) and Great Britain, for the purpose of showing the extensive areas of land awaiting development in that State. As a matter of fact, of the 1,000,000 square miles comprised in Western Australia, only about 17% has a rainfall comparable with that of the British Isles (i.e. over 20 inches), and of this area (but a little greater than that of the British Isles) no less than four-fifths is situated within the tropic.

A glance at a map of Australia will show that, after nearly a century of steady progress, settlement is still confined to certain definite areas. It will be worth while to consider the reasons for this distribution. The sketch-map (Fig. 58) indicates by the ruled areas those districts which are more than sparsely populated and contain about one inhabitant to the square mile.

What factor is common to all these areas? It will be seen that, with three or four exceptions, they all **lie outside the 15-inch isohyet.** Australians must always bear in mind that a large part of the continent, somewhere about 40%, will never support aught but a **pastoral occupation,** flourishing in rainy seasons, and only in the case of large holdings managing to tide over the drought years. Indeed, what can be expected with the 10-inch isohyet, sweeping from North-West Cape across the heart of the continent almost to Cloncurry, and then bending southwards to the Lower Murray? All to the south and west of this line, except a broad coastal area in the west (Swanland), and another around the South Australian

Gulfs, is beyond reclamation for close settlement on any large scale.[1]

With the United States as an example of what will presumably eventuate in Australia, let us attempt to define the limits of *close* settlement more accurately. We may omit all areas receiving less than 10 inches of rain

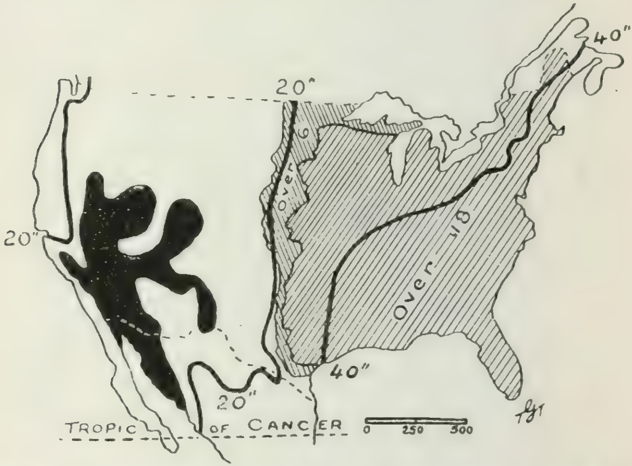

FIG. 59. Correlation of Rainfall and Population in U.S.A. The thick lines are isohyets of 40 and 20 inches. The black area has less than 10 inches of rain. The line rulings show the density of population and are based on Bartholomew's map.

per annum in this broad investigation. The question of **temperature** is also of importance, and admits of several methods of treatment. One may use a definite mean annual isotherm as a criterion. Referring to U.S.A., it is seen that the line 68° F. passes just north of New Orleans and Florida. It will be admitted that these districts are

[1] Certain exceptions, such as the mining settlements of Coolgardie, Cue, Broken Hill, &c., have prospered in the face of most unfavourable conditions, although they lie within the 10-inch isohyet.

not well suited for *continuous* out-of-door white labour, or at any rate British labour; and the white Australia policy at present does not favour 'dago' immigration from Southern Europe. In Australia this isotherm of 68° passes south of the Tropic of Capricorn,[1] so that one may safely take the latter as the northern limit of the most favourable areas for closer settlement in Australia.

Now let us tabulate these areas available for settlement by the British farmer. In the south a lower rainfall is necessary than in the north. They are shown approximately by the diagonally-ruled areas on the map (Fig. 58). (It is useful to remember that the British Isles have an area of 120,000 square miles.)

No exception is made for rugged or heavily timbered country in this list. Such will naturally be later portions of the State to be settled.

Table A.

Areas suitable for close settlement.

(Temperate lands suitable for wheat and similar crops.)

New South Wales (over 15 inches)	188,000	sq. miles.
Queensland (over 20 inches)	134,000	,,
Victoria (over 15 inches)	68,000	,,
West Australia (over 10 inches)	151,000	,,
Tasmania (under 40 inches)	16,000	,,
South Australia (over 10 inches)	60,000	,,
N. Territory	nil	nil
Total	617,000	sq. miles.

Let us now compare this area with the similar tract in U.S.A., and endeavour to draw a parallel between the growth of the latter and that foreshadowed in Australia.

In 1800 the United States had a population of 5,000,000 - which is much the same as that occupying Australia now—and during the past century (1800–1900) it has

[1] Valuable tropical crops such as sugar will probably long be confined to the NE. coast plain for reasons stated previously. This region in tropical Queensland (receiving over 30 inches) is about 50,000 sq. miles.

increased to 76,000,000. The distribution of the latter is controlled to a very great extent by the rainfall, as will be seen from the sketch-map (Fig. 59), where the '6 to the square mile' population-line almost coincides with the 20-inch isohyet and the 18 to the square mile population-line runs parallel and less than 100 miles to the east.

This 20-inch isohyet practically divides U.S.A. into equal areas of some 1,500,000 square miles each. In the western half (i.e. the twelve States including and west of Dakota, Nebraska, Colorado, and New Mexico) are distributed only seven per cent. of the whole population while 70,000,000 have settled in the well-watered eastern half.

In Australia, as we have seen, there are about 600,000 square miles of *temperate* agricultural country, or about one-third of that in U.S.A.[1] So that given the same rate of increase as in U.S.A.—which, however, is not likely to occur—Australia should have a population of some 20,000,000 white people at the end of the century.

If, however, we recognize the undoubted value of the considerable areas of fertile and reasonably watered country in the tropical portion of Australia, the larger colonies stand in a more favourable position. Without coloured labour, however, it is difficult to see how such crops as cotton, rice, tea, coffee, tobacco, and rubber can be grown with any great profit, even if supported by Government bounties; yet, as explained in an earlier section, these products are the main resources of regions with a similar climate.

We must differentiate the uniform and winter-rainfall regions from those experiencing winter-drought. The latter are much less useful.

[1] The Commonwealth Meteorologist arrives at the figure 500,000 from a consideration of the potential wheat belt in Australia. (*Federal Handbook*, 1914, p. 149.)

TABLE B.

(Total areas of land with more than 20″ rain annually.)

	Uniform or Winter Rains.	*Winter Drought.*	*Total over 20 inches.*
Queensland .	243,000	143,000	386,000
West Australia	70,000	106,000	176,000
N. Territory .	—	141,000	141,000
New S. Wales .	130,000	—	130,000
Victoria . .	55,000	—	55,000
Tasmania . .	25,000	—	25,000
South Australia	15,000	—	15,000
Totals .	538,000	390,000	928,000

Thus under present political conditions **New South Wales** is the most promising field for future settlement, with Queensland a close second, as shown on Table A. If the tropical areas are thrown open to inferior labour—which alone is profitable on a large scale—then **Queensland** occupies the most favourable position, while Northern Territory moves from the last to the third place.

It will be probably remarked that Australia must rely chiefly on her **pastoral area** for her future wealth. The more settled portion of Australia in the south-east has already suffered from over-stocking, but in the north and west there is still ample room for expansion. Though sheep prefer the less tropical portions, cattle thrive excellently in the far north, and it seems probable that it will be the latter class of stock which will increase in numbers to a greater degree in the future.

Before proceeding to gain some idea of the pastoral areas available in Australia some discussion of the rainfall maps (Figs. 13 and 17*a*)—on which this chapter is based—is necessary.

Not only the annual totals but also the **season and character** of the rainfall is important, especially in the most arid regions. The course of the ten-inch isohyet is now fairly well known, and runs approximately along the Tropic of Capricorn from North-West Cape to the Diamentina River in Queensland.

Unfortunately Canning's and other surveys have only corroborated my remarks in earlier editions as to the arid centre. The **Sandhill and Spinifex** country extends up to latitude 19° S. and touches the coast at Wollal. It extends in a south-east direction to Ooldea on the Trans-Australian Railway. To the east it reaches half across Northern Territory, and there is another large area north of Lake Eyre of the same hopeless character.

The increased **evaporation** in the north, together with the utter lack of reliability (see Chapter VII) of the rain, make the arid region reach in the north to the 15-inch or even to the 20-inch isohyet.

Luckily in the south the conditions are very much better. Wheat can grow with an annual rainfall of **just over ten inches**—and cattle and sheep can thrive on such dry areas—so that probably the **seven-inch isohyet** will be found to separate the useless from the useful lands of the continent in the south.

Inside this block of 910,000 square miles, there are only about 100,000 cattle and perhaps 250,000 sheep. These graze chiefly in the regions along the central belt near the Overland Telegraph—which passes between the two great sandhill desert regions.

Exactly **one-third of the continent** therefore carries **less than one per cent.** of the sheep and about the same proportion of the cattle. This is the result at the end of fifty years of pastoral occupation, and shows clearly that our interior is by no means a *rich* grazing country. At the same time future **conservation of water** in dams and wells will enable pastoralists to greatly increase the total of their flocks and herds. But it will never become one of the world's important pastoral regions.

The States may be classed approximately as follows in regard to their pastoral capabilities under present political conditions :[1]

Approximate Pastoral areas in sq. miles.
(Agricultural areas omitted.)

States.	*High Capacity.*	*Fair Capacity.*	*Very low.*	*Total.*
West Australia	300,000	176,000	350,000	826,000
Queensland .	367,000	69,000	—	436,000
N. Territory .	130,000	260,000	130,000	520,000
South Australia	120,000	90,000	110,000	320,000
New S. Wales .	77,000	45,000	—	122,000
Victoria . .	10,000	10,000	—	20,000
Tasmania . .	5,000	5,000	—	10,000
Totals .	999,000	636,000	590,000	2,225,000

In opening up a new country it is obvious that pioneer industries such as sheep and cattle rearing occupy lands which later on will be more economically utilized in other ways. For instance, a large portion of Tasmania now devoted to sheep will undoubtedly be converted into farms and orchards in the near future. In the table such potential agricultural regions are omitted.

To sum up the approximations I have attempted to demonstrate in this section. There is in Australia an area (400,000 square miles) about three times that of Great Britain, of sufficiently similar climate and rainfall to admit of *close settlement* for farming and allied industries. There is another 200,000 square miles receiving more than 10 inches in the south which is also suitable for wheat—though its environment does not resemble that of Britain. It will support a fairly close settlement. The population

[1] Based largely on the writer's Memoir, 'Climatic Control of Australian Production,' 1915, Melbourne.

on the area is still very scanty, though naturally the best lands have been alienated. Moreover, much included in the area is rocky and barren, the figures obtained depending purely on conditions of rainfall and climate generally.

An area of nearly 1,000,000 square miles has a rainfall greater than 20 inches per year, but unfortunately more than half of this tract lies north of the Tropic of Capricorn and cannot be profitably exploited without inferior labour. For instance, it can never under *white* labour compete with the similar agricultural lands of tropical India.

It may safely be assumed, however, that much will be utilized for raising cattle; while of drier areas more or less suitable for grazing, there are in addition probably over 1,000,000 square miles available.

If, however, we neglect political factors—such as the White Australia policy—and consider only the unrestrained potentialities of the Six States, we arrive at the succeeding table:

Potential Occupation of Australia.

State.	*Available for close white settlement.*	*Tropical agricultural lands.*	*Good pastoral lands.*	*Fair pastoral lands.*	*Almost useless lands.*	*Total.*
West Australia	150,000	negligible	300,000	176,000	350,000	976,000
Queensland .	134,000	100,000	367,000	69,000	nil	670,000
N. Territory .	nil	negligible	130,000	260,000	130,000	520,000
South Australia	60,000	nil	120,000	90,000	110,090	380,000
New S. Wales .	188,000	nil	77,000	45,000	nil	310,000
Victoria . .	68,000	nil	10,000	10,000	nil	88,000
Tasmania . .	16,000	nil	5,000	5,000	nil	26,000
Totals .	616,000	100,000	1,009,000	655,000	590,000	2,970,000
Per cent. .	21	3	34	22	20	100

These results may be condensed as follows:

About 42 % is arid—of which:

20 % of the whole is almost useless for stock.

22 % is fair pastoral country, except in bad droughts.

About 34 % is good pastoral country.

About 21 % is fair temperate farming country, suitable for close settlement of which:

13 % receives over 20 inches per annum.

8 % receives less than 20 inches per annum.

About 3 % (in Tropical Queensland) has a uniform rainfall through most of the year. The rest of the Tropics experiences a total drought for six months or more, and is much less favourable for tropical agriculture except where irrigation is possible.

The Great Coal Belt.

It has been stated that 'coal is the mother of industry and of population'. In the densely populated countries of Europe (i.e. England and Germany) the increase of population is owing to the mighty development of their manufactures. The French population tends to stagnation owing to her insufficient industrial power. Germany has twice as much coal as England, and twenty-five times as much as France.[1]

In our chief coal belt we have 165,572 million tons of coal—about the same as Great Britain. Here then is a guarantee of immense power in the future if we only *use it* well and *guard it* well.

Conclusion.

Here I close this brief study of the resources of Australia. I have viewed the problems which have arisen

[1] See *Fortnightly Review*, Feb., 1918.

from the economic point of view rather than from the political; from the geographer's rather than the farmer's standpoint. Australia must make the most of the garland of verdure which surrounds her arid interior. Water conservation and dry farming will broaden this garland. Intense cultivation will produce a yeoman class and promote decentralization. With regard to the tropics, although in the near future cattle will surely utilize the savannas, may we not look forward to the time when—escaping the errors of less fortunate countries—we allow a limited but contented population from a weaker race to develop our wasted northern areas?

INDEX

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